



CHEMICAL ENGINEERING

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2022

ESSENTIALS FOR THE CPI PROFESSIONAL
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Safety

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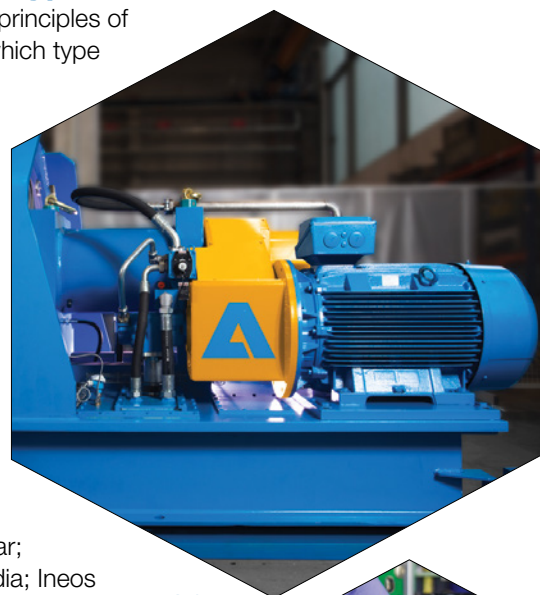
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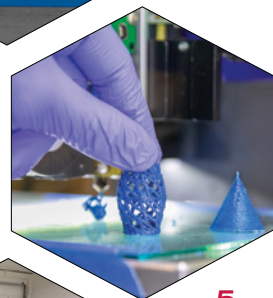
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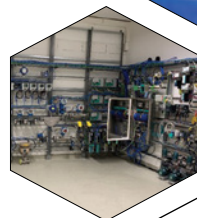
Advances in sliding-vane and internal-gear seal-less pump technologies can provide many benefits when compared to centrifugal pumps or more well-known positive-displacement pump options



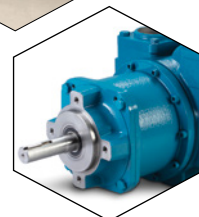
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Cover photo:
Courtesy of Andritz AG; The image shows a three-stage Kraus-Maffei Pusher Centrifuge from Andritz

Cover design:
Tara Bekman

Coming in September

Look for: **Feature Reports** on Emissions Control ; and Temperature Measurement and Control; A **Focus** on Compressors, Fans and Blowers; A **Facts at your Fingertips** on Gas Dispersion; a **Newsfront** on Modeling and Simulation Software; **New Products**; and much more

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 **VERIFIED**
 AUDIT

Driving environmental progress

The recent decision by the U.S. Supreme Court limiting the authority of the U.S. Environmental Protection Agency (EPA) to regulate emissions from power plants has many concerned about the effects the decision will have on efforts to address climate change and other environmental concerns. The majority opinion of the Court deems that the EPA does not have the authority for a broad cap on carbon dioxide emissions, but rather that only the U.S. Congress itself has such authority. (For more on the specifics of the Supreme Court ruling, see Ref. 1)

While the case before the Supreme Court was specifically about regulating power plants, concerns are that the ruling may be setting the groundwork as a precedent for how much authority the EPA or other federal agencies have over a spectrum of environmental regulations. For example, this fall in *Sackett v. EPA* the Court is scheduled to hear arguments involving how to determine if wetlands are part of the "waters of the U.S." under the Clean Water Act.

Impact on environmental progress

Regulations have played an important role in driving certain industrial practices to meet regulatory requirements. However, the level of impact that limiting the regulatory authority of federal agencies will have on climate-change and other environmental initiatives is uncertain, as there are other forces driving environmental progress.

A strong driving force toward environmental, social and governance (ESG) and sustainability goals is the increased importance placed on these goals by investors. A recent report by McKinsey & Company [2] says that leading investors consider ESG and sustainability to be integral parts of their portfolio strategies, and that they have become top priorities for executives in oil-and-gas and chemical companies. McKinsey's research shows that "90% of the top 20 global chemical companies have public commitments to reach net-zero emissions, near-zero emissions or carbon neutrality by 2050."

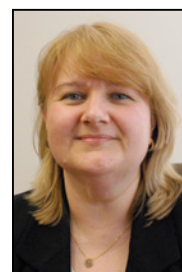
An example of this commitment is a recent announcement by Shell Chemicals Park Moerdijk, a subsidiary of Shell plc (www.shell.com). The company plans to invest "billions" in its chemical complex over the next ten years to reach net-zero emissions and produce more sustainable chemicals. In the announcement, the company cites that it is addressing the changing needs of its customers who want more low-carbon products and products made using recycled materials. The driving force is growing customer demand.

Numerous examples like this appear in *Chemical Engineering's* latest business and technology news, showing an increased focus on decarbonization, plastics recycling, storage solutions to better implement renewable energy resources and many more sustainable practices.

Investment management companies are also focused on ESG and sustainability. For example, BlackRock's (www.blackrock.com) chairman and CEO, Larry Fink, addressed these topics in his letter to CEOs this year [3], and wrote, "I believe the decarbonizing of the global economy is going to create the greatest investment opportunity of our lifetime. It will also leave behind the companies that don't adapt, regardless of what industry they are in."

Dorothy Lozowski, Editorial Director

1. Supreme Court Limits EPA Authority to Regulate Power Plant Emissions, www.powermag.com, June 30, 2022.
2. Sustainability value in chemicals: Market tailwinds versus ESG scores, www.mckinsey.com, July 11, 2022.
3. The Power of Capitalism, www.blackrock.com, 2022.

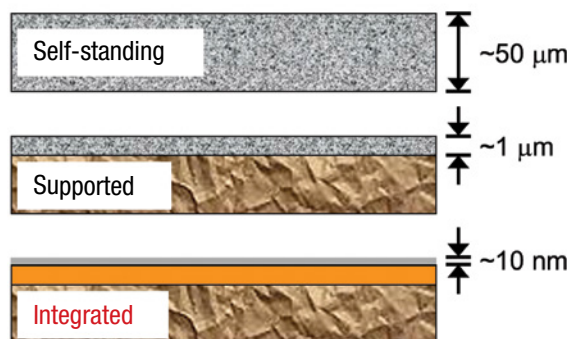


Hybrid membrane separates CO₂ with both high permeability and selectivity

Conventional gas-separation membranes normally exhibit a trade-off between selectivity and permeability — a practical limitation referred to as the Robeson upper bound. As a result, membranes designed to selectively remove relatively low concentrations of carbon dioxide from natural gas or fluegas are inherently hampered by a low CO₂ flux through the membrane.

To overcome this constraint, researchers from Sintef (Trondheim, Norway; www.sintef.no), in collaboration with professor Richard Spon-tak at North Carolina State University (Raleigh; www.ncsu.edu) and professor Liyuan Deng at the Norwegian University of Science and Technology (Trondheim; www.ntou.no), have developed membranes that integrate an ultrathin, highly CO₂-selective surface layer with a highly permeable, but low selectivity, polymer membrane in a concept referred to as hybrid-integrated (HI) membrane technology (diagram). As described in a recent article in *Science*, the surface layer consists of surface-grown polyamines that concentrate CO₂ from the target gas stream. The CO₂ is quickly transported through the dense polymer membrane and the underlying macroporous support. “The resulting membranes retain high CO₂ permeability with CO₂ selectivities increased by more than 150-fold over the parent membranes,” says Marius Sandru, Sintef researcher and

Different Types of Carbon-Capture Polymer Membranes



(not drawn to scale)

lead author of the study.

In laboratory-scale tests, performed using membranes with ~20 cm² area and gas flowrates of ~30 L/h (fully humidified 10/90 CO₂/N₂ feed typical of fluegas), CO₂ permeabilities and CO₂/N₂ selectivities of up to ~1,000 Barrer and ~1,000, respectively, have been measured. The membranes have also been studied using mixtures of CH₄ and CO₂ (typical of biogas plants), achieving selectivities of up to ~500.

“The next stage is the stepwise upscaling of membrane area,” says Sandru. Membranes with 500-cm² area will be fabricated in the ongoing CO₂-Hybrid project and tested using real fluegas in static tests, followed by field testing in a coal-/natural gas-fired Waste2Energy pilot facility. The goal is to achieve a 90% CO₂ capture efficiency with 95% CO₂ purity.

Biodegradable corn-based adhesive is non-toxic, with tunable properties

A new class of adhesives being developed by the startup gluECO Adhesives LLC (Ashburnham, Mass.; www.glueco-adhesives.com) is based on corn proteins and has a host of environmentally friendly properties, such as biodegradability and the ability to be easily removed in paper repulping processes. The patent-pending technology behind the adhesives was invented in the laboratory of Jon Wilker, a professor and researcher at Purdue University (West Lafayette, Ind.; www.purdue.edu). It has been licensed for commercial development by gluECO.

The adhesives are based on zein, a protein extracted from a byproduct of corn milling. The zein-based adhesives are non-toxic, biodegradable, and have been

certified as GRAS (generally recognized as safe) by the U.S. Food and Drug Administration. Also, the company says the zein adhesives can easily be separated from the slurry of recycled paper that is intended for the production of new paper.

The properties of the adhesives are tunable, which means the end products can be adjusted for strength, flexibility and performance in extreme temperature, as well as moisture and high-vibration conditions, gluECO says. As further advantages, gluECO points out that the adhesives have antimicrobial properties and can be produced with a smaller carbon footprint than petroleum-derived alternatives.

The company is planning to launch the adhesives in the fourth quarter of 2022.

Edited by:
Gerald Ondrey

BIOMETHANE

Last month, NextChem, a subsidiary of Maire Tecnimont S.p.A. (Rome, Italy; www.mairetecnimont.com) was awarded a contract by ENGIE subsidiary Storengy (Bois-Colombes Cedex, France; www.storengy.com) to perform an advanced basic-engineering study for a plant that will produce second-generation biomethane from the pyrogasification of waste wood. Once the project has reached the final investment decision targeted by the end of 2022 and is granted the related permitting, NextChem, in association with another Maire Tecnimont Group subsidiary, will act as an engineering, procurement and construction (EPC) contractor for the methanation package of the project, which is set to be implemented in Le Havre, France as part of the Salamander project. The plant will produce 11,000 ton/yr of equivalent biomethane.

NextChem will be responsible for the engineering and cost estimating for the synthesis gas (syngas) purification, methanation unit and methane upgrading of the plant. Comessa (Strasbourg, France; www.comessa.com) will be responsible for the design and supply of the chemical reactor. The technology to be used in the plant has already been successfully applied to the Gaya pilot plant near Lyon, owned by ENGIE, which validated the feasibility to produce biomethane. This will be the first commercial project in the world of its kind to inject into the grid methane produced through pyrogasification of waste wood.

P-RECOVERY

Kemira Oyj (Helsinki, Finland; www.kemira.com) and Veolia Wasser Deutschland GmbH (Leipzig, Germany; www.veolia.de) recently an-

(Continues on p. 6)

nounced their collaboration in the full-scale technology assessment of the new phosphorus recovery technology ViviMag. ViviMag is a patented technology to recover phosphorus and other valuable resources, such as iron, from sewage sludge. The technology has been developed by Wetsus (Leeuwarden, the Netherlands; www.wetus.nl), the European center of excellence for sustainable water technology, and Technical University Delft (www.tudelft.nl), in cooperation with Kemira, several other private companies and municipal water companies.

Kemira Oyj and Veolia Wasser Deutschland will conduct the first ViviMag industrial pilot trial at the wastewater treatment plant of Schönebeck, Germany, during the second half of 2022.

FLUOROELASTOMERS

Solvay S.A. (Brussels, Belgium) recently introduced a new portfolio of high-performance Tecnoflon peroxide curable fluoroelastomers (FKM) produced without the use of fluorosurfactants — a type of per- and polyfluoroalkyl substances (PFAS) used as process aids. The proprietary new technology, called NFS (non-fluorosurfactant), marks a breakthrough in FKM polymerization and aligns with the company's sustainability roadmap Solvay One Planet as Solvay is setting the direction for the fluoropolymers industry to a more sustainable economy.

Last month, Solvay started the mass sampling of the new Tecnoflon peroxide curable grades to allow the market to test and adopt the NFS technology before the global roll-out of the new portfolio. The company aims to transition Tecnoflon FKM to NFS by

A more-sensitive way to differentiate chiral compounds

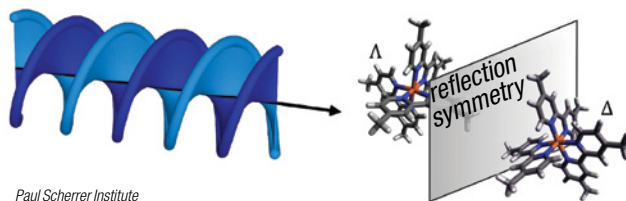
Circular dichroism (CD) is the established method for distinguishing between enantiomers — the optical isomers of molecules that are mirror images of each other. In this approach, circularly polarized light is passed through the sample and is absorbed differently by the enantiomers. Although CD is widely used in analytical chemistry, in biochemical research, and in the pharmaceutical and food industries, the signals are very weak: the light absorption of two enantiomers differs by just under 0.1%. There are various strategies for amplifying the signals, but these are only suitable if the sample is available in the gas phase. Most studies in chemistry and biochemistry, however, are carried out in liquid solutions.

Now, Swiss researchers from the Paul Scherrer Institute (PSI; Villigen; www.psi.ch), EPF Lausanne (www.epfl.ch) and the University of Geneva (www.unige.ch) have demonstrated a new method, which was reported in a recent issue of *Nature Photonics*. The new method exploits so-called helical dichroism (HD), which relies on the shape (helical) of the radiation's wavefront, rather than its polarization.

At the Swiss Light Source (SLS) at PSI, the researchers were able, for the first time, to show that en-

antiomers can also be distinguished from each other using helical X-ray light. At the cSAXS beamline of SLS, they demonstrated this on a sample of the chiral metal complex iron-tris-bipyridine in powdered form (diagram). The signal they obtained was several orders of magnitude stronger than what can be achieved with CD. HD can also be used in liquid solutions and thus fulfills the prerequisite for applications in chemical analysis. The ability to distinguish enantiomers is also an important tool when separating them.

The researchers were able to create light with the desired properties with spiral-zone plates, diffractive X-ray lenses through which the X-rays pass before hitting the sample. "With the spiral zone plates, we were able, in a very elegant way, to give our X-ray light the desired shape and thus an orbital angular momentum. The beams we create in this way are also referred to as optical vortices," says PSI researcher Benedikt Rösner, who designed and fabricated the spiral zone plates for this experiment.

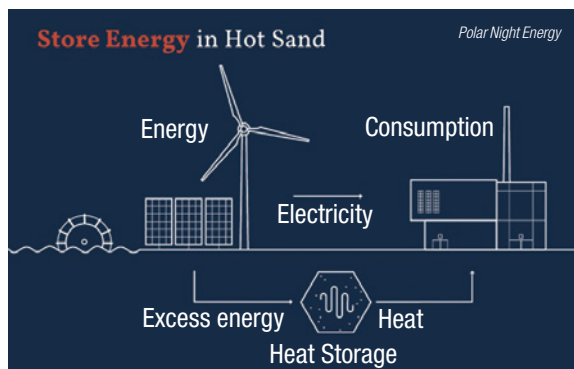


Paul Scherrer Institute

Commercial debut for sand-based energy storage

Last month, operation began at Polar Night Energy Oy's (Tampere, Finland; www.polarnightenergy.com) first commercial sand-based thermal-energy storage system. The thermal storage system, which is located at the Vatajankoski power plant, is now producing low-emission district heating to the city of Kankaanpää in Western Finland. The unit has a heating power of 100 kW and an energy-storage capacity of 8 MWh.

The storage system is an insulated steel tank (4-m wide and 7-m tall) that contains 100 tons of sand, and a network of pipes. Additional equipment, such as automation components, valves and fan and a heat exchanger (or steam generator), are located outside. The operating principle is very simple: electricity is converted to heat by an electrical-resistance heater that heats air in a closed-loop piping system. When the hot air is circulated through the storage, the heat is transferred to the sand. The sand can be heated to temperatures of 500–600°C, and stored for long periods of time. The storage is unloaded by blow-



ing cold air through the piping, and then the heated air can be used to convert water to process steam or to heat district-heating water in an air-to-water heat exchanger.

The use of sand is said to be an effective solution for reducing CO₂ emissions. According to a 2020 report by Mission Innovation (<http://mission-innovation.net>), sand-based high-temperature energy storage could save more than 100 million metric tons of CO₂ equivalents (CO₂e). Saved emissions would be around 3% of the current emissions of the whole E.U., the company says.

(Continues on p. 8)

the first quarter of 2024.

Peroxide-curable FKM rubbers are key to many critical performance applications in industries from automotive and aerospace, oil-and-gas, chemical processing, to electronics and healthcare. Typical components include seals, gaskets, O-rings and hoses.

METHANOL

The European Union Innovation Fund has selected Project Air, a unique production facility for sustainable methanol in Stenungsund, Sweden, as one of 17 large-scale green-technology projects to be granted more than €1.8 billion. Project Air, which is a collaboration between Perstorp AB (Malmö, Sweden; www.perstorp.com), Fortum Oy (Espoo, Finland; www.fortum.com) and Uniper SE (Düsseldorf, Germany; www.uniper.energy), has applied for €97 million and the total investment is expected to amount to more than €230 million.

Project Air is based on innovative usage of existing technology in a large-scale industrial application. To produce sustainable methanol, the facility utilizes significant amounts of CO₂ and other residue streams recovered from Perstorp's ongoing operations, biogas from new dedicated plants together with hydrogen from a new large electrolysis plant. Further, existing wastewater treatment will be utilized as feed water for the electrolysis. All electrical energy for the combined project will be renewable based. Large-scale production is slated for 2026.

Project Air will be built at Perstorp's existing facilities in Stenungsund, strengthening the regional chemicals industry cluster, Hållbar Kemi 2030. The sustainable methanol from Project Air will be used to produce chemical products.

ALGAE OIL

To save the world's fish stocks and oceans, scien-

Upcycling of waste ABS into 3D-printable material with enhanced properties

In an advancement toward circularity for commodity plastics, researchers at the Oak Ridge National Laboratory (ORNL; Oak Ridge, Tenn.; www.ornl.gov) have developed a method for upcycling the commodity thermoplastic acrylonitrile butadiene styrene (ABS) into an ABS-vitrimer material that can be used in fused-filament fabrication (FFF), a popular 3D-printing technique. When used in 3D printing, the resulting material produces stronger, tougher and more solvent-resistant three-dimensional components (photo) that are themselves easily recyclable.

"We need fundamental discoveries to overcome the challenges of increased costs and deteriorating material properties associated with recycling," says Tomonori Saito, ORNL researcher and corresponding author on the study. "Our goal was to develop an easily adoptable strategy that reuses plastic waste to create a more valuable material instead of generating fresh plastic."

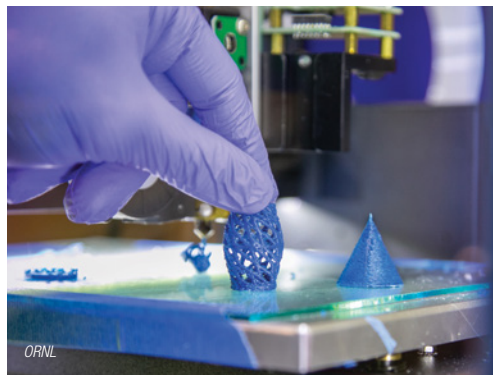
ABS is used in a wide range of end-use products, including automobile components, table-tennis balls, and LEGO blocks. Led by Saito, the ORNL team generated ABS-vitrimers by implementing thiol-ene "click" chemistry to functionalize butadiene segments with cysteamine, followed by reacting with a short-chain dialdehyde (glutaraldehyde) to produce ABS-vitrimer.

Vitrimers feature networks of dynamic

covalent bonds that can undergo thermally activated bond-exchange reactions. They exhibit mechanical robustness and chemical resistance because of their covalent network formation, but vitrimers can also be malleable by reconfiguring reversible cross-links through the associative bond exchange at elevated temperature, making it recyclable, the ORNL team says.

The ABS-vitrimers also have added solvent resistance, which enables their easy separation from mixed, unsorted plastic waste commonly encountered in recycling scenarios. The team dissolved mixed plastic waste in various solvents, and in each experiment, upcycled ABS maintained its structure, while all other plastics, including ABS, completely dissolved.

The researchers expect that the value-enhancing recycling process for the ABS-vitrimers will also reduce CO₂-equivalent emissions by 65% compared to incineration.



Extending the operating temperature of biological phosphorus removal

Currently, enhanced biological phosphorus removal (EBPR) techniques in municipal wastewater-treatment plants (WWTPs) do not work well at temperatures above 25°C, which is common in warm countries. This limitation is expected to extend to more countries with the advent of global warming.

To "future-proof" phosphorus removal, scientists from the Singapore Center for Environmental Life Sciences Engineering (SCELSE; www.scelse.sg), Nanyang Technological University (NTU), Singapore and the National University of Singapore, have developed a technique that removes phosphorus from WWTPs at temperatures of 30–35°C. The method, described in a recent issue of Water Research, is based on the bacterial genus *Candidatus Accumulibacter*, which accumulate phosphorus from wastewater and store it as

polyphosphate granules.

In the study, two laboratory-scale sequencing batch reactors (SBRs) were operated in parallel at 30°C and 35°C, respectively, for over 300 days. "Employing a slow-feeding strategy and sufficiently high carbon input into biological reactors, we effectively limited the carbon uptake rates of competing bacteria. This allowed *Accumulibacter* to flourish and benefited a stable and efficient process, representing basic conditions suitable for future full-scale treatment plants," says NTU professor Stefan Wuertz, deputy center director of SCELSE, who led the study.

Unlike other P-removal methods, the SCELSE-developed method does not involve chemicals, such as iron and aluminum coagulants. These methods produce a large volume of inert sludge that needs to be treated and disposed of afterwards.

(Continues on p. 10)

tists are searching for sustainable ways to make healthy nutritional products, such as omega-3 fatty acids, from fast-growing microalgae. New research at Flinders University (Adelaide, South Australia; www.flinders.edu.au) has discovered a simple, low-cost and effective way to extract high-value bioactive substances and other products from single-cell algae oil. The researchers focused on thraustochytrids, because this single-celled algae can produce over 50% of its weight as triglycerides.

In the study, described in a recent issue of *ACS Sustainable Chemistry & Engineering*, the scientists reported a way to enrich the saturated triglycerides produced in thraustochytrids. The method involves the direct reaction of elemental sulfur with the algae-oil extract. The sulfur copolymerizes with over 90% of the unsaturated triglycerides into a class of materials already used in such applications as Li-S battery cathodes, slow-release fertilizers and insulation. The unreacted oil is enriched in saturated triglycerides, which can further be separated by extraction and use, for example, in biodiesel-fuel production

PURIFYING PYROLYSIS OIL

Last month, BASF SE (Ludwigshafen, Germany; www.basf.com) launched PuriCycle, a new line of products for the purification of most complex waste-plastics-pyrolysis feeds. The PuriCycle portfolio includes new catalysts and adsorbents that were developed to selectively remove or convert a wide range of impurities in pyrolysis oils and enable downstream processing of circular plastics streams. PuriCycle can help users meet industry compositional compliance standards, benefit from high efficiency purification and upgrading solutions and increase their flexibility in the chemical recycling process of plastics, says BASF.

Purification of pyrolysis oils obtained from waste plastics is said to be among the most demanding technical tasks in chemical plastics recycling. Impurities, such as halogen, nitrogen, oxygen and sulfur compounds — but also higher levels of reactive components such as dienes — complicate the downstream use and impose strict limitations on the further processing of such streams in the production of new materials. ■

Limpet tooth inspires strongest biomaterial

An interdisciplinary team of biologists, chemists and engineers from the University of Portsmouth (U.K.; www.port.ac.uk) have become the first to successfully grow a limpet-inspired biomaterial with extreme strength. The common limpet (*Patella vulgata*) is a small, snail-like mollusk with a tongue covered with microscopic teeth that are used for scraping food from rocks. The teeth are a hard, flexible composite of chitin and goethite ($\alpha\text{-FeO(OH)}$) that, in 2015, was found to be the strongest known biomaterial — much stronger than spider silk and comparable to man-made substances.

The team has now successfully mimicked limpet tooth formation in the laboratory and used it to create a new composite biomaterial, which is described in a study published last month in *Nature Communications*.

“Fully synthetic composites like Kevlar are widely used, but the manufacturing processes can be toxic, and the materials difficult and expensive to recycle,” says lead author Robin Rumney, from the University’s School of Pharmacy and Biomedical Sciences. “Here we have a material that potentially is much more sustainable in

terms of how it’s sourced and made, and at the end of its life can be biodegraded.”

The key to the limpet tooth’s strength is thought to be due to a structure that combines flexible, tightly packed fibers of a scaffold material (chitin) interspersed with fine crystals of goethite. Those fibers are laced through each other in much the same way that carbon fibers are used to strengthen plastic.

The researchers developed methods that allowed cell populations to grow outside of their natural environment (*ex vivo*) on serum-coated glass, onto which they deposited chitin and iron oxide. After two weeks, the material self-organized into structures that resembled the limpet organ, known as the radula, which makes the teeth. Ribbons of teeth could also be grown from tissue samples and individual teeth from populations containing stem cells.

After successfully replicating the limpet tooth formation, the team was then able to produce samples of biomaterial 0.5-cm wide by mineralizing a sheet of chitin. Now that proof-of-concept has been established, the researchers will explore scaleup and manufacturing possibilities.

Biosynthesis of renewable, high-energy-density, cyclopropane-based fuels

Cyclopropane-functionalized hydrocarbons can be excellent fuels because of their high energy densities, but organic synthesis of such fuels is difficult. In work recently published in the journal *Joule*, a research team led by Jay Keasling at the Joint Bioenergy Institute (JBEI; Emeryville, Calif.; www.jbei.org) and Lawrence Berkeley National Laboratory (Berkeley, Calif.; www.lbl.gov) has demonstrated a sustainable biosynthetic route to polycyclopropanated fatty-acid methyl esters (POP-FAMES). These compounds can be made into fuels with energy densities of 50 MJ/L or more (Jet A, the common kerosene-based aviation fuel, has about 35 MJ/L).

The potential energy in the strained, three-carbon-rings in polycyclopropanated molecules translates into more energy for combustion than can be achieved with the larger ring structures or carbon-carbon chains typically found in fuels, the researchers point out. In addition, these structures enable fuel molecules to pack tightly together in a small volume, increasing the mass — and therefore the total energy — of fuel

that fits in a given tank.

To produce POP-FAMES, the scientists first identified a set of iterative polyketide synthases (iPKSs) — enzymes that are capable of producing the desired polycyclopropanated structures — in *Streptomyces* bacteria species, and expressed them in *Streptomyces coelicolor* to obtain POP-fatty acids. The team further engineered the bacteria to increase the production of the POP-fatty acids 22-fold, and finally, produced the methyl ester derivatives.

Project leader Keasling says, “This biosynthetic pathway provides a clean route to highly energy-dense fuels that, prior to this work, could only be produced from petroleum using a highly toxic synthesis process.”

The research team is working on generating much higher volumes of the POP-FAMES for testing in rocket engines and elsewhere. The ultimate objective is to engineer the process into a workhorse bacteria strain that could produce large quantities of POP molecules from plant waste food sources (for example, inedible agricultural residue and brush cleared for wildfire prevention). ■

LINEUP

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Plant Watch

Johnson Matthey to build U.K. gigafactory for H₂ fuel-cell components

July 18, 2022 — Johnson Matthey plc (JM; London; www.matthey.com) is building an £80-million gigafactory at its existing site in Royston, U.K. to manufacture hydrogen fuel-cell components. The gigafactory will initially be capable of manufacturing 3 GW of proton-exchange-membrane (PEM) fuel-cell components annually. The site is expected to begin operation in the first half of 2024.

Huntsman starts up MDI splitter in Geismar

July 14, 2022 — Huntsman Corp. (The Woodlands, Tex.; www.huntsman.com) started commercial operation of a new methylene diphenyl diisocyanate (MDI) splitter at its Geismar site in Louisiana. The \$180-million splitter gives Huntsman the ability to produce additional differentiated grades from the crude MDI manufactured at the plant, thereby enabling growth in the automotive, furniture, construction, adhesives and coatings markets.

Umicore to construct battery-materials plant in Canada

July 13, 2022 — Umicore N.V. (Brussels, Belgium; www.umicore.com) plans to construct a plant for cathode active battery materials (CAM) and their precursor materials (pCAM) in Ontario, Canada. The planned facility would be the first of its kind in North America, combining cathode and precursor materials manufacturing at a large industrial scale. Umicore is targeting to start construction in 2023, with production startup at the end of 2025.

AkzoNobel invests €20 million to expand production capacities in France

July 12, 2022 — AkzoNobel N.V. (Amsterdam, the Netherlands; www.akzonobel.com) is investing €20 million to expand production at two of its sites in France. A total of €15 million will be spent on the company's aerospace coatings facility in Pamiers, where production capacity is being boosted by 50%. The other €5 million will be spent on improving production flexibility at the decorative-paints site in Montataire. Building work is expected to start by the end of 2023, with the new installations at both locations due to be operational in early 2025.

BASF doubles its polymer dispersions capacity in Dahej, India

July 12, 2022 — BASF SE (Ludwigshafen, Germany; www.basf.com) completed the installation and startup of a new acrylic-dispersions production line in Dahej, India, serving the coatings, construction, adhesives and paper industries for South Asian markets.

BASF began production of polymer dispersions in Dahej, in October 2014, and this additional production line will almost double its capacity.

Air Liquide invests in biomethane production in China

July 12, 2022 — Air Liquide S.A. (Paris; www.airliquide.com) has invested in the group's first biomethane-production unit in China, which is expected to begin operation by the end of 2022. Located in Huai'an City in Jiangsu Province, the unit will have a production capacity of 75 GWh/yr. This new unit will produce biogas from agricultural and livestock waste coming from local farms and purify it into biomethane for injection into the city gas grid for household and commercial use.

Ube begins basic design for DMC and EMC plant construction in the U.S.

July 6, 2022 — Ube Corp. (Tokyo; www.ube.co.jp) is studying the feasibility of constructing a new plant in Louisiana to produce commercial-scale volumes of dimethyl carbonate (DMC) and ethyl methyl carbonate (EMC). The production capacity is planned to be 100,000 metric tons per year (m.t./yr) of DMC and 40,000 m.t./yr of EMC derived from DMC. A final investment decision is to be made in the first half of 2023, with operations expected to commence in the second half of 2025.

Versalis and Forever Plast to construct plastics recycling facility in Italy

July 6, 2022 — Versalis S.p.A. (San Donato Milanese, Italy; versalis.eni.com) and Forever Plast have signed a new agreement related to the construction of an advanced mechanical-recycling unit for selected post-consumer plastics, in particular polystyrene and high-density polyethylene. Located at Versalis' Porto Marghera industrial site, the new plant will process 50,000 m.t./yr of pre-sorted waste into recycled polymer compounds once it comes onstream in 2024.

Ineos significantly expanding PAO production in Texas

June 28, 2022 — Ineos Group Ltd. (London; www.ineos.com) is executing a phased 50% expansion of its LaPorte, Tex. high-viscosity polyalphaolefin (PAO) unit, which will be fully effective by mid-2025. The unit was initially built with a capacity of 20,000 m.t./yr, and was debottlenecked last year to reach 25,000 m.t./yr. With this further investment, it will expand again to almost 40,00 m.t./yr. Ineos also recently started up a low-viscosity PAO unit in Chocolate Bayou, Tex. With a production capacity of 120,000 m.t./yr, this facility is said to be the world's largest single PAO train.



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Henkel opens new adhesives plant in Mexico

June 28, 2022 — Henkel AG (Düsseldorf, Germany; www.henkel.com) opened a new plant for hot-melt adhesives in Guadalupe, Nuevo Leon, Mexico. The 30,000-m² facility will mainly produce pressure-sensitive and non-pressure-sensitive hot-melt adhesives for use in consumer goods and packaging.

BASF to increase U.S. production capacity for specialty amines

June 28, 2022 — BASF will increase the production capacity for key specialty amines manufactured at its Geismar, La. site. After completion of the capacity expansion by mid-2023, BASF will be able to produce more polyetheramines and tertiary amines, complementing its global network of specialty-amines production plants in Ludwigshafen, Germany and Nanjing, China.

Mergers & Acquisitions

AkzoNobel acquires coatings assets from Lankwitzer Lackfabrik

July 6, 2022 — AkzoNobel is bolstering its automotive performance-coatings

portfolio by acquiring the wheel liquid-coatings business of Lankwitzer Lackfabrik GmbH. Completion of the transaction is expected before the end of 2022. Lankwitzer's Rims and Wheel business operates a manufacturing site in Leipzig, Germany, as well as laboratories in Germany and Turkey.

Neste acquires European rights to Alterra plastics-recycling process

June 27, 2022 — Neste Corp. (Espoo, Finland; www.neste.com) purchased the European rights to Alterra Energy's (Akron, Ohio; www.alterraenergy.com) proprietary thermochemical technology for the liquefaction of hard-to-recycle plastics into an intermediate product that can be further refined into raw materials for plastics and polymers. Together with Ravago, Neste also plans to set up a joint venture (JV) to deploy the Alterra Energy technology in Vlissingen, the Netherlands.

PKN Orlen receives clearance for merger with Lotos Group

June 24, 2022 — PKN Orlen (Plock, Poland; www.orken.pl) has secured the European Commission's clearance for

its intended merger with Lotos Group (Gdansk, Poland; www.lotos.pl). The antitrust clearance marks a leap forward for the merger, which will create an organization with annual revenue of approximately PLN 250 billion (around \$53 billion). The new, expanded Orlen Group will be based on an integrated value chain, from upstream petroleum exploration and production, through refining and petrochemical production.

Air Liquide and Siemens Energy create hydrogen electrolyzer JV

Siemens Energy (Munich, Germany; www.siemens-energy.com) and Air Liquide created a JV dedicated to the production of industrial-scale PEM electrolyzers in Europe. Production is expected to begin in the second half of 2023 and ramp-up to an annual production capacity of 3 GW by 2025. Air Liquide will take 25.1% of the JV, and Siemens Energy will hold the remaining 74.9% stake. The new JV will be headquartered in Berlin, Germany. One of the JV's first projects is the 200-MW Normand'Hy electrolyzer project in Normandy, France. ■

Mary Page Bailey

Achieving Balance in Combustion

New hardware combined with monitoring technologies can help optimize combustion now and in the carbon-conscious future

Combustion has long been a delicate balancing act. Chemical processors want their combustion systems to be fuel efficient and available for use, while at the same time, they must also be safe and meet emissions standards. Unfortunately, these requisites are often at odds with each other. Recently, the trend toward reducing carbon emissions is throwing yet another challenge at combustion management. However, thanks to new technologies and the inclusion of combustion monitoring, processors may find it easier to achieve harmonious balance, even in a carbon-conscious culture.

"The general issue with combustion is that as processors try to meet production goals, they are forced into a situation where minding emissions permits, efficiency and regulations nearly forces them to run in a state that is at odds with what would be the easiest and most efficient operation and would provide them with the most reliability and best asset lifetime," says Neil Widmer, senior business development manager with

Emerson (Shakopee, Minn.; www.emerson.com). "This forces them into a very narrow operating range."

While oxides of nitrogen (NOx) emissions have been the major pollutant to fret over, the trend toward fuel efficiency and decarbonization threatens to make this delicate combustion balance even more precarious. "NOx emissions are now back on the table as an ongoing challenge because there are new rules in place that require NOx reductions for a large number of heaters and fired equipment," notes Matthew Martin, chief R&D scientist with XRG Technologies (Tulsa, Okla.; www.xrgtechnologies.com). "CO₂ is a new challenge due to the focus on decarbonization because unless you're burning ammonia or hydrogen, any combustion process makes CO₂."

Chuck Baukal, director of the Koch Engineered Solutions Institute (Tulsa, Okla.; www.kochengineeredolutions.com) agrees that this is a developing trend to watch: "Pollution emissions are always an issue for the chemical processing industry, but one of the newest challenges is a great deal of attention on CO₂ emissions. So now

folks are considering changing their fuels to something like hydrogen or ammonia, which don't produce CO₂ emissions."

Mark Hannum, manager of Innovation and Research and Development with Fives North American Combustion (Cleveland, Ohio; www.fivesgroup.com), adds: "While there are currently not many regulations regarding CO₂ emissions in the U.S., many processors are creating their own corporate goals and/or anticipating future regulations and trying to determine what they can do now to 'future proof' their businesses and processes in a new application or when installing new equipment. They want to do this without sacrificing any of their other needs regarding safety, reliability and efficiency."

Achieving emission goals

Combustion-equipment providers are continually improving existing equipment to assist with reaching tighter emission regulations. For example, there are new burner technologies that produce lower NOx

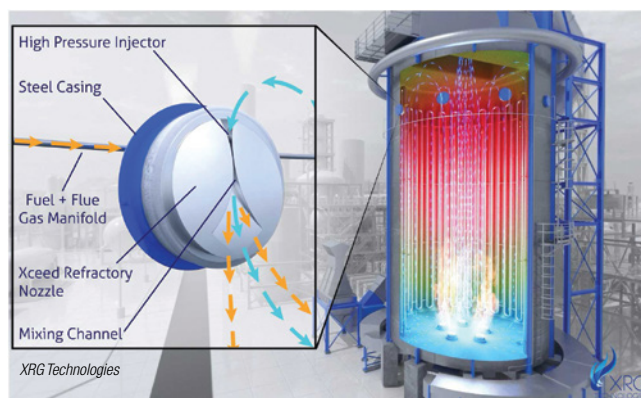


FIGURE 2. XRG's Xceed system provides a modification to the combustion system for fired heaters, furnaces and boilers that changes the way in which combustion takes place to distributed combustion or disbursed combustion, allowing for NOx and CO₂ reductions by changing the heat transfer inside the system



FIGURE 1. EcoFornax LE and LEX (shown here) burners both rely on lean premix. The LE also employs fuel staging and dilute combustion mixing technologies to accomplish emissions and efficiency goals



FIGURE 3. Zeeco's ultra-low NOx technologies can handle high-hydrogen and other fuels. Recent enhancements to the technologies make them more maintainable and make better use of internal fluegas inside of the furnace

emissions and selective catalytic reduction (SCR) equipment can be added to further reduce the pollutant. "Additionally, any efficiency improvement you make to combustion equipment or fired heaters results in less carbon emissions, because burning more efficiently uses less fuel," notes XRG's Martin. "Improving efficiency is a quick win when the goal is reducing CO₂."

In addition, he says, many processors can see up to a 20% improvement on the top end in combustion and fuel efficiency by upgrading their fired heaters with technologies that pre-heat combustion air or by re-vamping the heat-recovery section in the heater. "These methods reduce fuel consumption while allowing more throughput. So, specific to CO₂ production, the amount of the pollutant per unit of product goes down," says Martin.

Although, returning to that delicate balance, using pre-heated combustion air will increase efficiency, therefore reducing CO₂ emissions, but the use of pre-heated combustion air along with the use of carbon-based fuels tends to increase NOx emissions.

For this reason, some companies are developing technologies that help processors potentially reduce both NOx and CO₂, while still increasing efficiency and allowing flexibility with fuels. "For medium- or low-temperature process heaters, we have equipment that will allow us to have low emissions of NOx and CO₂, even when we preheat combustion air," says Hannum. "Our EcoFornax line is amenable to having air preheat and still providing really low emissions" (Figure 1).

EcoFornax LE and LEX burners both rely on lean premix, while the LE also employs fuel staging and dilute combustion mixing technologies to accomplish emissions and efficiency goals. "We have put these on a number of process heaters, such as glycol heaters, crude oil heaters, titanium tetrachloride vaporizers and even some field-erected, high-pressure boilers," says Hannum. "Additionally, they are flexible regarding fuel, so if a processor wanted to switch from natural gas to a fuel with less carbon, this line would have advantages for CO₂ reduction, as well."

XRG offers its Xceed system, which provides a modification to the combustion system for fired heaters, furnaces and boilers that changes the way in which combustion takes place to distributed combustion or disbursed combustion, allowing for increased efficiency, as well as NOx and CO₂ reductions by changing the heat transfer inside the system (Figure 2).

"This is a physical change you make to your existing system," says Martin. "It involves specialized nozzles that work with the burners in the combustion system you already have. This means the existing burner stays in place, so start-up and shut-down routines remain the same. After the system has begun operation and has reached steady state, the device is turned on and it changes the nature of combustion. It is low temperature and very dilute, so it produces very little NOx and the heat-transfer uniformity of the process is greatly increased. This eliminates hot spots in the fired equipment, so it can operate to a higher capacity without exceeding temperature limits."

The lower NOx emissions it enables mean that users can recover more heat and increase combustion

pre-heat air. "These features make Xceed an enabling technology for CO₂ reduction, but it does not itself reduce CO₂," explains Martin. "The system is capable of firing hydrogen or ammonia, so it could be used to replace part of your hydrocarbon fuels with hydrogen or ammonia firing in order to reduce CO₂ emissions."

Zeeco, Inc., (Broken Arrow, Okla.; www.zeeco.com) offers combustion equipment that features ultra-low NOx technologies with the ability to handle high-hydrogen and other fuels, says Rex Isaacs, chief technology officer with the company. "While we have been doing some high-hydrogen applications for 20 to 30 years, we've recently made some enhancements to those technologies to make them more maintainable and to make better use of internal fluegas inside of the furnace. The ability to inert the H₂, which burns at a higher adiabatic flame than other fuels, delays combustion and also achieves lower NOx. At the same time, it reduces the local temperature inside the burner, which reduces the damage to the metallurgy, increasing reliability of the equipment" (Figure 3).

Koch Engineered Solutions also offers a wall burner for ethylene applications that enables 100% H₂ firing, with lower NOx performance compared to traditional ethylene wall burner technology. This also eliminates flashback, which can be an operational concern and cause maintenance issues for customers, says KES's Baukal.

"We've also engineered the Solex Burner, which can achieve single-digit NOx emissions regardless of the fuel composition and independent of furnace temperature," explains Ryan Morgan, vice president of OnPoint, a Koch Engineered Solutions com-

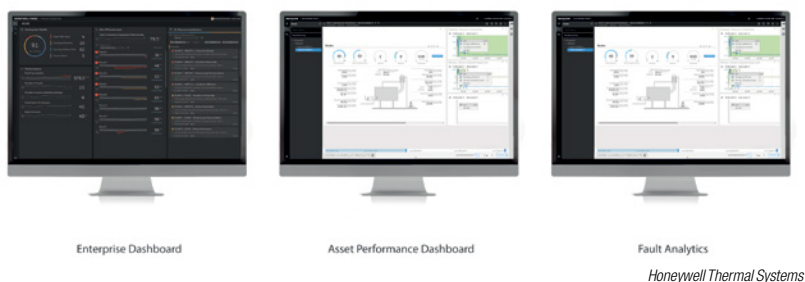


FIGURE 4. Thermal IQ remote monitoring software records, archives and analyzes thermal systems to provide real-time visibility into the thermal performance of combustion and actionable intelligence



FIGURE 5. Emerson's OCX8800 Combustion Fluegas Transmitter provides a continuous, accurate measurement of O₂ and combustibles remaining in fluegases to permit a higher level of optimization

pany. "The burner is designed with two significant combustion zones to achieve these emissions levels from start up to full capacity with minimal CO emissions. In addition, the burner's compact flame lengths solve many issues ultra-low NOx burner technologies face in today's market."

Preparing for CO₂ reduction

While it may not yet be feasible to switch to carbon-free fuels due to the capital expense of replacing or retrofitting an existing combustion system for unknown emissions goals, combustion experts say there are steps you can take to figure out where you currently are and what you need to do to reach corporate decarbonization goals and future government regulations. Fortunately, these same steps also help optimize the current combustion process.

"We are having a very 'wild, wild west' moment regarding CO₂ emissions," says Dale Smith, global growth leader, Connected Combustion Services, with Honeywell Thermal Solutions (Houston; www.honeywell.com). "Many companies are voluntarily making sustainability part of their corporate goals. We also know some regulations are coming and that California has already pushed some very aggressive emissions targets out there."

"What I suggest is taking a deep breath and collecting data on where you currently stand," Smith continues. "Figure out your baselines: what are your burners doing, what you are emitting, how much fuel are you using, how are you actually perform-

ing? Once you have your baselines, you can determine where you have gaps and where you can improve and from there you can create a roadmap for the future and whether that requires investments or not."

Todd Ellington, director, Global Product Marketing, with Honeywell Thermal Solutions, agrees. "We have hardware and control devices that are capable of low NOx emissions and helping to improve efficiency, so if you are already taking ad-

vantage of these low-emission burners and they are performing well, adding something like Thermal IQ or remote monitoring software that is recording, archiving and analyzing your system can provide real-time visibility into the thermal performance of your combustion and actionable intelligence. It becomes an enabler for reliability, safety and emissions control and provides early warnings for predictive actions. If you can predict, you can be more efficient and effective now and see where you need to go in the future. That's the power of data. It optimizes not only how we use our thermal equipment, but how we use our money and our energy and provides a roadmap for the path we will need to take in the future" (Figure 4).

Optimizing combustion systems

The bonus of monitoring combustion to find a path toward the future is that it also helps processors optimize their current combustion process, which aids in achieving that elusive balance of efficiency, reliability and emissions control, say the experts.

"Today we strive to operate at better efficiency. However, with different staging techniques for low-NOx burners and because today's combustion tends to run leaner in excess air, which limits both NOx and CO₂ emissions, but raises potential for CO emissions or unsafe fuel-rich conditions, it's very important to make sure combustion sys-

tems are running properly maintenance- and safety-wise, but also to ensure the proper air-to-fuel ratio," explains Emerson's Widmer.

He says in-situ oxygen probes, such as the zirconium-based Rosemount 6888 In-Situ Oxygen Transmitter provide a continuous, accurate measurement of the oxygen remaining in fluegases coming from any combustion process (Figure 5). Accurate measurements of furnace exhaust excess oxygen are directly related to and critical for maintaining proper air-to-fuel ratio, resulting in reduced energy costs, increased safety and lower emissions.

Additionally, the OCX8800 Combustion Fluegas Transmitter provides a continuous, accurate measurement of oxygen and combustibles remaining in fluegases. This close-coupled extractive analyzer permits a higher level of optimization. "It's important to measure and monitor both oxygen and combustibles and to do so in a way that allows you to make changes in the controls so that you have some wiggle room in the setpoint of the oxygen," Widmer says.

This is helpful, he continues, because most trim controllers are very good at maintaining the oxygen level, but not at optimizing it. "Some days you might have very good fuel sources or combustion conditions so you could run oxygen at 1% without any combustibles or CO emissions breakthrough, but other days, conditions might not be as optimal. This type of monitoring with the ability to manually make changes allows you to optimize for the combustion conditions that day," says Widmer.

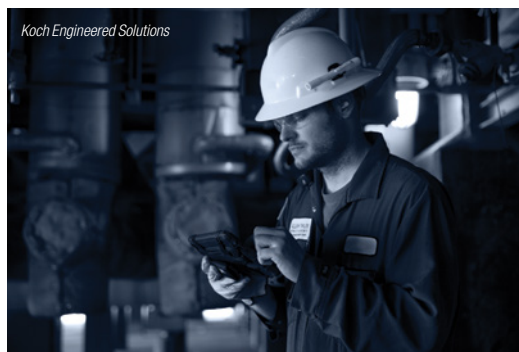


FIGURE 6. OnPoint's EMBER solution uses data from existing instrumentation and links those data to proprietary calculations to provide operators with recommendations on how to adjust their combustion equipment to be more efficient, increase throughput and reduce emissions

Additionally, combustion providers may offer advanced analytics to produce solutions that can help processors drive increased throughput, improved efficiency and reduced emissions. KES's Morgan says On-Point offers one such solution called EMBER that uses data from the plant to help optimize process heating operations (Figure 6). EMBER uses data from existing instrumentation and links those data to proprietary calculations, which are hosted in the cloud. That information is used to provide operators with recommendations on how to adjust their combustion equipment to be more efficient, increase throughput and reduce emissions.

"Depending on the company's priorities, EMBER can help them manage those goals while continually benchmarking against the KPIs [key performance indicators] they monitor across the process unit," explains Morgan. "For example, you can track energy intensity while also keeping track of the amount of emissions when trying to maximize throughput. Our solution will produce the recommendations to align those objectives and help operators meet those with the changing operating conditions they face every day."

And, finally, a burner management system (BMS) is essential to providing optimized and safe performance, notes Joe Medeski, Technical Sales Engineer with Profire Energy (Lindon, Utah; www.profireenergy.com). "The ability to have deeper visibility into the combustion operation and receive actionable insights and make informed decisions is essential to optimizing the balance between safety, efficiency and emissions," he says. "You want a BMS, such as the Profire 3100 burner management system, that sends an alert when you are close to setpoints so you can take these alarms and notifications into consideration and make any changes needed to keep things from going astray. And, having pre-determined setpoints is also helpful to ensure that optimized operating conditions are repeatable in the same exact manner over a long period of time."

■
Joy Le Pree

Pipes, Tubes and Fittings



ESCO Tool

A portable pipe beveling tool prepares pipe for welding

The Wart Millhog Portable Pipe Beveler (photo) is a right-angle I.D. clamping tool for performing any angle of end prep on 0.75 in. I.D. to 4-in. O.D. pipe of different schedules. Because it mounts securely into the pipe I.D. using a self-centering draw rod assembly, it can bevel, face and bore different pipe thicknesses simultaneously to help assure high-integrity weld joints. Producing precise square and beveled pipe ends with ± 0.001 -in. accuracy, the beveler lets users weld pipe O.D.s that have different schedules. Easy to operate, it comes with pneumatic or electric motors, requires no cutting fluids, and is ideally suited for onsite applications. A wide range of TiN-coated blades are available. — *ESCO Tool, A Unit of Esco Technologies, Inc., Holliston, Mass.*

www.escotool.com

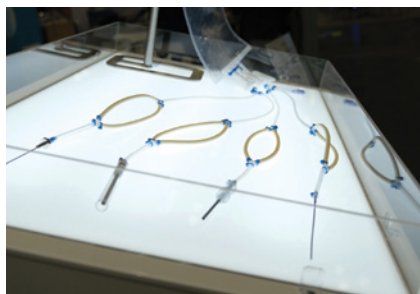


Fortress Technology

Pipeline metal detector facilitates hygiene standards

Catering to the ever-changing food landscape and new product developments (NPD), this company has upgraded its Pipeline Metal Detector (photo). With optimized metal detection sensitivity and high hygiene standards, this detector protects productivity while providing users with safe, uncontaminated products. Available in standard 2-, 3-, 4- and 5-in. pipe diameters, the latest machines are engineered to detect metal in high-viscosity foods and liquids (such as meat products, gravies, syrups and more) to eliminate contaminants in the processing line. The systems are IP69K rated to prevent bacteria from accumulating. Data capture and Contact Reporter software ensures the system satisfies quality assurance (QA) mandates and compliance with North American processing requirements. — *Fortress Technology Ltd., Toronto, Ont., Canada*

www.fortresstechnology.com



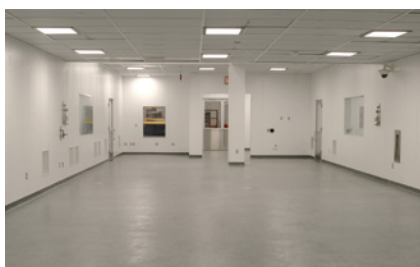
Venair Group

sembly in state-of-the-art, ISO7/Class 10,000 cleanrooms and with sterility treatments. Vena Flexip is especially recommended for the transport of liquid or semi-liquid fluids in the food, cosmetics, chemical and pharmaceutical industries. It has a good resistance, especially in fatty or oily foods and glycols, as well as in alcoholic beverages. Shapes, such as elbows and bends, can also be manufactured to adapt to any installation. Vena Flexpure is a hose with a polytetrafluoroethylene (PTFE) inner layer that makes it highly resistant to both acids and some basic clean-in-place (CIP) solutions. Thanks to its ultra-flexible smooth-bore construction, it is ideal for processing powders, liquids and semi-liquids in applications where a highly hygienic design and good mechanical performance are required. — *Venair Group, Barcelona, Spain*

www.venair.com

A new tubing manufacturing plant starting up

Last October, the preparation of floors, ceilings, exterior walls, electric service and plumbing lines were nearly finished at this company's new Warrington manufacturing facility (photo). With the operational infrastructure approaching completion, additional cleanroom construction can move forward swiftly to help reach the goal of making and shipping tubing. The 90,000-ft² building, sitting on seven acres, houses several individual clean rooms for extruding AdvantaSil high-purity silicone tubing and braid-reinforced hose and AdvantaFlex biopharmaceutical grade thermoplastic elastomer (TPE) tubing. Most finished tubing will be transported to the company's Southampton operations for post-production work involving single-use tubing assemblies. Following completion of the project, the company anticipates tripling its production capabilities for silicone and TPE tubing. In February, a new silicone-tubing extrusion line and a new TPE-tubing extrusion line began producing AdvantaSil silicone



New Age Industries

Tubing products for biotechnology applications

This company offers a new range of tubing (photo) and single-use as-



Parker Hannifin Manufacturing Germany

tubing and braid-reinforced hose and AdvantaFlex weldable and sealable TPE tubing. — *NewAge Industries, Inc., Southampton, Pa.*
www.newageindustries.com

Corrosion protection for tube fittings and adapters

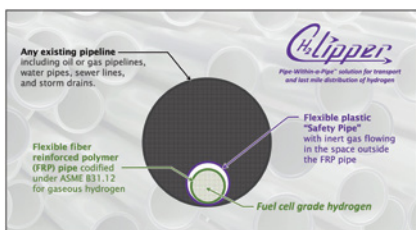
Last February, this company introduced the proprietary ToughShield Plus zinc-nickel surface treatment for all tube fittings and adapters worldwide. The plating provides excellent resistance for increased corrosion prevention while maintaining optimum properties and assembly values. ToughShield Plus is said to be the first commercially available standard plating system for fluid power systems to provide up to 3,000 h of resistance to red corrosion per ASTM B117 neutral salt-spray testing. ToughShield Plus has been designed to save users time and money with extended tube fitting and adapter life, easier maintenance and increased resistance to corrosion migration to other system components. ToughShield Plus complies with the leading industry standards such as DIN and SAE, as well as the environmental standards RoHs, REACH and ELV. — *Parker Hannifin Manufacturing Germany GmbH & Co. KG, Kaarst, Germany*
www.parker.com



GF Piping Systems



Bee Valve



H₂ Clipper

Weld PVC piping with this IR-based system

The IR PVC-U (photo) is said to be the world's first infrared (IR) welded PVC-U (unplasticized polyvinyl chloride) piping system that prepares reliable joints in a machine-controlled process. The newly introduced IR PVC-U system is suitable for the chemical process industries and water-treatment applications. It combines two fields of this company's expertise, bringing together the heritage of the PVC-U piping system and its IR-welding machines. The company developed the infrared welded PVC-U pressure piping system to allow a machine-controlled process, minimizing the risk of human error while making reliable, reproducible joints. This new joining technology for PVC-U uses no cements, contributing to environmental protection while improving the chemical resistance. The new system consists of the necessary

weldable fittings, valves and pipes designed for an operating pressure of 16 bars. In the beginning, two metric dimensions, d25 and d50, will be available. — *GF Piping Systems, Schaffhausen, Switzerland*
www.gfps.com

A wide range of Schedule 80 polypropylene pipe fittings

This company offers a full line of Schedule 80 pipe fittings (photo). These fittings are produced from glass-reinforced polypropylene for strength and durability. Polypropylene is the lightest of the thermoplastics. It has good resistance to most acids and is also a non-conductor of electricity. These Schedule 80 fittings are available in sizes from 3/8 to 3 in. Fitting configurations include tees, elbows, crosses, nipples, bushings, couplings, caps and plugs. A complete line of hose, tube, pipe and nozzle fittings in a variety of materials are also available. — *Bee Valve Inc., Elyria, Ohio*
www.beevalve.com

Patented pipe technology for H₂ distribution

Earlier this year, this company was awarded a patent for its Pipe-Within-A-Pipe technology (photo) for safely and efficiently transporting hydrogen up to 1,000 miles inside virtually any existing oil and gas pipeline, water pipe, sewer line, storm drain or other pipelines. This technology is said to provide the safest, most cost-effective, most readily deployable, and scalable way to address end-user delivery of fuel-cell-grade H₂. The approach covered by the patent utilizes flexible pipe rated for H₂ use by the American Society of Mechanical Engineers (ASME) with a 50-year useful life at 2,500 psi. That pipe is located inside a slightly larger diameter one — referred to as a "safety pipe" — that runs an inert gas in between the two pipes to constantly sweep for hydrogen molecules. With a capacity to preserve purity levels of 99.7% or higher, the new technology will help to ensure the required purity levels needed for use of hydrogen in fuel-cell electric cars, buses, trucks and locomotives. — *H₂ Clipper, Inc., Santa Barbara, Calif.*
www.h2clipper.com

Gerald Ondrey

‘Eye it Before You Buy It’: The Invention of Cellophane

Transparent polymer film started with an accident . . . and spurred a packaging revolution

One night in Paris, in 1900, Swiss chemist Jacques Brandenberger was enjoying dinner in a restaurant when he noticed that a fellow patron had spilled a glass of wine. As waiters scrambled to clear the table, it occurred to Brandenberger that the process of removing and replacing the soiled tablecloth was time-consuming and inefficient. He began to mull an application of research he had been conducting into the organic polymer cellulose. Brandenberger conjectured that he could spray liquid viscose, created from natural sources of regenerated cellulose, onto fabric and thereby create waterproof coatings for tablecloths and other textiles.

Brandenberger's initial experiments in this vein were promising, but ultimately disappointing. The fabric coatings he produced were indeed waterproof, but the coatings proved far too stiff to maintain fabric pliability. But Brandenberger noticed something of interest: the coatings could be peeled off the fabrics without difficulty, yielding a thin, diaphanous film. He began to conceive that the value in his material lay not only in its water resistance but also in its transparency.

Commercial juggernaut

By 1912, having enhanced his material (especially through the addition of glycerin, to soften it), Brandenberger had patented his product and designed a manufacturing process for it, selling the commercial rights to the firm Comptoir des Textiles Artificiels (CTA). Brandenberger called the film “Cellophane,” a portmanteau of cellulose and the French word diaphane, meaning transparent. The early adopters of this transparent film were food product manufacturers, such as the American candy manufacturer, Whitman's, which was a major customer by 1912. Companies like this recognized cellophane's potential to revolutionize the packaging and retailing of perishable consumer goods.

Intrigued by the vast potential of this product, the DuPont company

purchased the exclusive rights to make and sell cellophane in the U.S. in 1923. In 1924, DuPont chemist William Hale Church reformulated the transparent film, developing a nitrocellulose lacquer that rendered it not only waterproof but more moisture-proof, enhancing its fresh-food preservation properties.

DuPont's innovations also extended to production. Initially, making cellophane required the time-consuming dissolution of cellulose from materials like wood, celery or cotton in alkali and carbon disulfide to make viscose, prior to taking the liquid to a cellulose state via an acid bath. Within a few years, however, DuPont had invented machines that enabled the mass production of cellophane, ensuring a vast supply for what would become a booming packaging market. Indeed, these developments catalyzed explosive growth of DuPont's sales of cellophane to food manufacturers — between 1928 and 1930, sales of cellophane tripled. By 1938, the “magical” transparent film accounted for 10% of DuPont's sales and 25% of its profits. The product you could “see right through” had become a commercial juggernaut.

Cellophane's emergence as a packaging innovation for the consumer market coincided with, and encouraged, the rise of self-service retailing, particularly of food products. In the early 20th century, customers typically purchased fresh foods from open-air markets, where quality was uneven and food waste high. Grocers sold customers canned products, or fresh foods that were selected and wrapped by store clerks. The introduction of cellophane wrapping, especially when coupled with refrigerated store shelving, allowed sellers to present fresh goods in packaging that connoted cleanliness, enhanced food safety and quality control, reduced ambient odors, and allowed for buyer's easy access without the involvement of a clerk.

Most significantly, cellophane enabled consumers to see what they were buying and to make purchases



FIGURE 1. A 1945 magazine advertisement touts the transparent property of cellophane biopolymer

ing decisions based on visual inputs such as colors, textures and evident freshness. DuPont's own consumer research found that 85% of food purchasing decisions were made by customers visually scanning products in store. Advertising of the period encouraged shoppers, bluntly, to “eye it before you buy it” (Figure 1). And when developments to cellophane and competing products in the 1940s ensured that meat could be wrapped to allow for an optimal balance between moisture control and oxygen penetration, the provision of fresh red meat outside the butcher's counter further ensured cellophane's packaging dominance.

This dominance did not survive the 20th century. Cheaper, petroleum-based films, such as polyethylene for baked goods and polyvinyl chloride for meat packaging, gradually ate into wood-based cellophane's market share. By the 1980s, production of cellophane was almost halted. But in recent years, cellophane production has enjoyed a modest resurgence. Its complete biodegradability stands in contrast with the plastic products that, in the minds of consumers, fill landfills, allowing consumers to “eye it before they buy it,” in a new way. ■

Edited by Scott Jenkins

Editor's note: This content is created by the research and curation team at the Science History Institute (SHI; Philadelphia, Pa.; www.sciencehistory.org).

Heat-Transfer Fluid System Venting

Department Editor: Scott Jenkins

Heat transfer fluids (HTFs) provide heating and cooling of process equipment, including reactors, autoclaves, distillation columns, reboilers, mixers and dryers. HTF system designs should provide for effective system venting, both of residual water at startup and of degradation products during operation.

Water concerns

When commissioning new HTF systems (Figure 1), a primary concern should be the effects of water: new systems can be vulnerable to excessive pressures from residual water. Hydrostatic pressure tests (leak checks) conducted on the system during manufacture or onsite after maintenance can be a typical water source. Complete water removal can be hindered by traps and piping elevation changes. The best system designs provide piping installations with slopes toward strategically placed low-point drains. After water is drained, but prior to filling, the system may be further dried by purging with warm, dry air (or N_2) through the system's circuits until the exiting gas dewpoint reaches -34 to -40°C , indicating moisture has been adequately dried. Close attention to the drying process will significantly reduce the time needed to reach the intended high operating temperatures at start-up.

Removing moisture at start-up

Prior to circulation, ensure the cold liquid level of the HTF in the system is adequate. This is typically indicated by the expansion-tank liquid level instrument (Figure 1). Next, heat the liquid slowly while circulating throughout all piping circuits with the assumption that water content may be excessive. Valve A is closed, and valves B and C are open. The HTF is circulated through the expansion tank and heats to just above 100°C . This temperature forces the moisture to flash into the vapor space of the expansion tank. Valve E is open, and the ingress of inert gas sweeps the water vapors from the vapor space downstream to a catch tank or flare

system. The process continues until moisture symptoms — including pump cavitation, erratic flowrate at the discharge side of the pump, and rattling, knocking and boiling sounds in the expansion tank and pipe — subside.

Once the HTF is deemed adequately dried, the fluid should be capable of continued heating to higher operating temperatures. Typical valve alignment during normal operation is for valves A and B to be open, and valves C and E to be closed. This valve placement allows a lower temperature in the expansion tank (commonly about 25% of system volume), where its thermal degradation rate is negligible.

Venting degradation products

In operation, the HTF deteriorates at increasing rates as the operating temperatures approach the bulk operating maximum for the specific HTF, altering the condition and composition of the HTF. Thermal degradation leads to the formation of both high-boiling compounds, which increase fluid viscosity and potential solids formation that increase risks of coke or fouling deposits, and low-boiling compounds that decrease the fluid's viscosity and that have boiling points lower than the boiling range of the HTF. Additionally, increasing low-boiling content can lead to flashpoint depression by 45°C or more.

The low boilers can be managed by routine system venting. Systems are best vented only when the concentration of low boilers exceeds recommended limits based on sample analysis of the fluid.

The same procedure is followed when commissioning a new system, except higher temperatures are needed. For many organic HTFs, the venting procedure is conducted at fluid temperatures near 180 to 200°C . This temperature range sup-

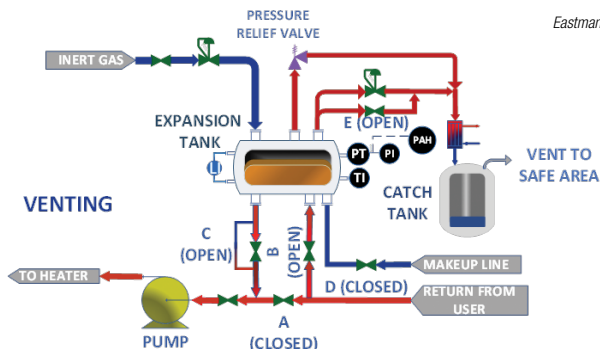


FIGURE 1. Heat-transfer fluid systems need to be vented for residual water at start-up and for fluid degradation products during operation

ports flashing into the vapor phase and separation of the low boilers from the heat transfer fluid for removal without incurring a significant loss of the HTF components. With valve A closed and valves B and C open, all the fluid flows through the expansion tank. This process raises the fluid temperature in the expansion tank and increases the partial pressures of the low-boiling degradation products. This allows the low boilers to flash into the vapor phase, where their removal is supported by opening valve E. Inert gas can be used to efficiently sweep those vapors across the surface of the liquid and out of the vent line, where they can be condensed and collected for disposal.

Circulation through the expansion tank also ensures that all HTF benefits from reducing levels of low-boilers.

After the venting process, return to the typical valve alignment for normal operation, where valves A and B are open, and valves C and E are closed. This arrangement provides for the thermal expansion and contraction of the HTF volume to and from the expansion tank with temperature changes. Continual venting and purging is not recommended, as this can deplete fractions of the HTF itself, creating related changes in its properties, performance and life expectancy. ■

Editor's note: This content was drafted by Kapil Bathla, a product development and customer technical support specialist at Eastman Chemical Co. (Kingsport, Tenn.; www.eastman.com).

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X-Raying The Patient: Gamma Scanning Vapor Cross-Flow Channeling

Henry Kister shares lessons learned from troubleshooting distillation towers

In 1988, the author led a team to troubleshoot a chemical tower that was revamped to achieve a small increase in capacity (up to 4%) by increasing the tray hole areas from 8.5% to 13% of the active area. In addition, radii were added at the bottom of the downcomers to smooth the exit of liquid and reduce downcomer backup. Strangely, instead of gaining capacity, it lost 5% capacity.

Before 1992, the mechanism of vapor cross-flow channeling (VCFC) on sieve and valve trays was not recognized by the industry. The author inquired around, and everyone was telling him that the capacity reduction should not have happened. There was one lead, as yet considered unlikely, that suggested that VCFC could be taking place, a mechanism well-known in bubble-cap trays. The author was following this lead.

In VCFC (Figure 1) the hydraulic gradient on the tray induces preferential rise of vapor near the outlet and middle of the tray, and forms a vapor-deficient region near the inlet to the tray. The high vapor velocities near the tray outlet step up entrainment, while the low vapor velocities near the tray inlet induce weeping. Interaction between adjacent trays accelerates both the outlet entrainment and the inlet weeping. The result is excessive entrainment and premature flooding at the tray middle and outlet, simultaneous with weeping from the tray inlet, accompanied by a loss of efficiency and turndown. The theory was that increasing the tray open area on the trays led to the onset of VCFC and consequent premature flooding on the trays.

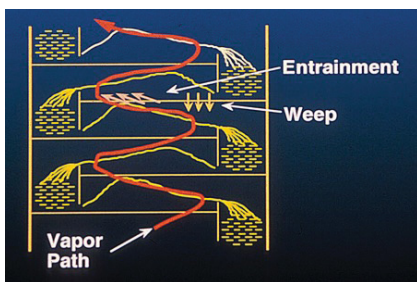


FIGURE 1. This diagram depicts vapor cross-flow channeling (VCFC)

The challenge was to test this theory. Gamma scanning was the most promising technique, but no one had experience with applying gamma scans for diagnosing VCFC, nor any idea as to how to do it. So it was decided to brainstorm together with Tru-Tec (now part of Tracerco) who had extensive gamma scanning expertise. Understanding the challenge, Tru-Tec lined up their three top experts, and together with the client's top experts and the author, met in Tru-Tec LaPorte's office. The meeting started about 3 p.m. and lasted for a few tedious hours. A lot of ideas and stimulating brainstorming were tossed around, but no breakthroughs. People began to wonder if there would be any resolution.

Just then, one of the Tru-Tec experts spoke. "Looks like we have brainstormed for a few hours and got nowhere. Maybe we are doing it all wrong. So let me suggest another way." Then he continued, "Not far from here there is an excellent Mexican Restaurant called Don Key. They have fabulous food, but what is more important, is they have an excellent beverage called Don'KeyRita. It is similar to Margarita, except that it kicks like a donkey. After one or two of these, we may get more creative and come up with a winning idea." His motion was unanimously and enthusiastically accepted.

Not only did we enjoy a delicious meal and Don'KeyRitas, but we left with a plan that everyone was happy with — and laid the foundations to the quantitative scanning that is still used to troubleshoot channeling.

The winning idea was to scan three different chords along the flow path length, both under flooded and unflooded conditions, and to apply quantitative analysis to derive froth heights, froth densities and liquid heads. From the liquid heads, hydraulic gradients can be inferred. The details are described elsewhere

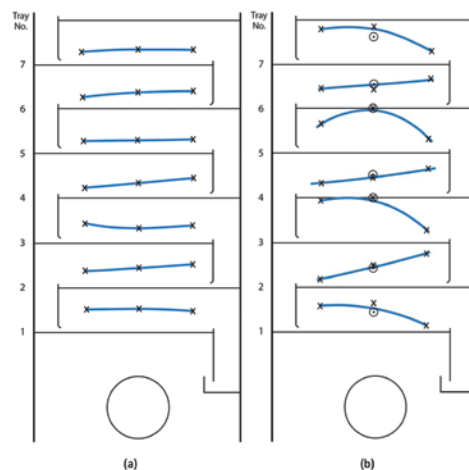


FIGURE 2. Clear liquid heights derived from three gamma scan chords along the flow path length are plotted on a to-scale column sketch. Tray liquid head values derived from quantitative analysis of gamma scans are plotted so that a liquid head of half the tray spacing is plotted as a point on the tray above. Zero liquid head is plotted as a point on the tray floor. Hydraulic gradients can be inferred from the diagram (a) Unflooded (b) Flooded

[1,2]. The results are shown in Figure 2, where all the tray dimensions are drawn to scale. Tray liquid head values derived from quantitative analysis of gamma scans are plotted so that a liquid head of half the tray spacing is plotted as a point on the tray above. Zero liquid head is plotted as a point on the tray floor.

In the unflooded scans (Figure 2a), hydraulic liquid gradients are flat or slight, sloping from tray inlet to outlet. Upon flood initiation (Figure 2b), the hydraulic liquid gradients on the odd trays become very steep, especially between the middle and outlet. The even trays (trays 2, 4, and 6), show large uniform hydraulic gradients stretching from inlet to outlet at flood initiation.

This intensification of the hydraulic gradients strongly supported VCFC as the root cause of the observed premature flood. From an unlikely hypothesis, VCFC became the leading theory. Based on this diagnosis, minor modifications were made to tower auxiliaries that permitted raising tower pressure. With VCFC inducing a premature entrainment flood, raising tower pressure reinstated the lost capacity. Prior to the

modifications, raising the pressure did not improve capacity because the trays were bottlenecked simultaneously by downcomer backup (which was debottlenecked by adding the downcomer radii) and by entrainment flood.

The takeaway: When dealing with a challenging problem, a change of environment from a four-wall meeting room to a more pleasant surrounding may help usher in a creative solution. ■

Edited by Dorothy Lozowski

About the Tower Doctor

"The Tower Doctor" is the honorary title bestowed upon the author of this article in 2002 by Richard Darton, professor of Engineering in Oxford University and chair of the European Distillation Network. "When a tower is not well," says Darton, "people call Henry to diagnose the illness and find a remedy. He arrives with his doctor's bag, examines the patient-

tower, measures its temperature and pulse, gets radiography to get an inside look. Then comes his diagnosis and cure. Towers treated by Henry mostly get better very quickly."

Being son to two medical doctors who were blessed with phenomenal diagnosis ability, the author aspired to live up to this special honorary title. Like with medical doctors, some illnesses were a struggle to diagnose, others were easier. All were exciting. This column will reminisce through some of the more entertaining cases. They may not have seemed entertaining at the time, but looking back at them, they leave unforgettable memories and raise a smile or two. One great aspect of being a tower doctor, one gets to work with and learn from some of the greatest engineers and operators that contributed so much to the chemical industry. We hope that this column can pass some of the fun, excite-

ment and lessons learned to future troubleshooters and tower doctors.

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Author



Henry Z. Kister is a senior fellow and the director of fractionation technology at Fluor Corp. (3 Polaris Way, Aliso Viejo, CA; Phone: 949-349-4679; Email: henry.kister@fluor.com). He has over 35 years of experience in design, troubleshooting, revamping, field consulting, control and startup of fractionation processes and equipment. Kister is the author of three books, the distillation equipment chapter in Perry's Handbook, and over 130 articles, and has taught the IChemE-sponsored "Practical Distillation Technology" course more than 530 times in 26 countries. A recipient of several awards, Kister obtained his B.E. and M.E. degrees from the University of New South Wales in Australia. He is a member of the NAE, a Fellow of IChemE and AIChE, and serves on the FRI Technical Advisory and Design Practices.

Scrolling or Pushing?

Choosing the Right Type of Filtration Centrifuge

Understanding the working principles of scrolling and pushing centrifuges can help when deciding which type to use. Feed properties and other factors also play a role

**Malte Junker
and Peter
Schmidt**

Andritz Separation
GmbH

IN BRIEF

TECHNOLOGY AND
OPERATING PRINCIPLES

FEEDING CONDITIONS

CAKES, MOISTURE AND
WASHING

FILTRATE QUALITY

MAINTENANCE AND
OPERATION

CONCLUDING REMARKS

When looking for a proven solution for mechanical dewatering, you will most likely come across centrifuges. In particular, filtration centrifuges, such as pusher or screen-scroll centrifuges, have made a name for themselves due to their continuous operating mode and their versatile field of application. In this article, we discuss the main differences between these popular centrifuges to help answer the question: “Scrolling or pushing — which filtration centrifuge fits my process?” To find the answer, we introduce the two most common continuous-filtration centrifuges — the pusher centrifuge and the screen-scroll centrifuge — and explain their advantages and disadvantages in order to derive practical decision criteria for using them.

The question of which combination of technologies makes sense, or even which technologies make sense for a particular process step, cannot be answered reliably in a general way. This is because there are, of course, different ways of conducting solid-liquid separation. Many of these ways are not mutually exclusive, but there is a selection of technologies whose reasonable sequencing combines to create a system that works efficiently.

However, some statements can be made that are at least frequently true. In many cases, for energy and budget reasons, it makes sense to provide at least two-stage solid-liquid separation, which is divided into a thermal and a mechanical separation stage. The decision in favor of specific technologies is considerably more complex, because, on the one hand, the material parameters of the system (density, viscosity, particle size and so on) must be observed, and on the other hand, the objective of the separation step, the value of the end product and the local conditions must also be considered.

For non-compressible or moderately compressible solids with average particle diameters larger than 80 μm , continuous filtration centrifuges have proven to be an efficient solution, as they allow very good dewatering on the one hand, and a high throughput in relation to the investment costs on the other hand [1].

Technology and operating principles

As shown in Figure 1, there are no significant differences between a pusher centrifuge and a screen-scroll centrifuge at first glance when viewed from the outside.

Both machines are filled via a feed pipe, and the solids are ejected at the front, with



FIGURE 1. A direct comparison of a pusher centrifuge (left) and a screen-roll centrifuge (right) does not reveal significant differences from the outside

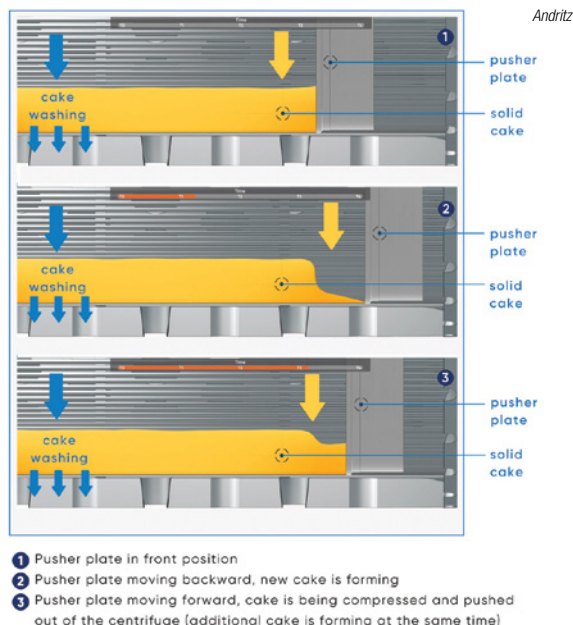


FIGURE 2. The sequence shown here demonstrates the operating principle of a pusher centrifuge

the filtrate usually leaving the centrifuge tangentially. On the drive side, the machines are also very similar at first glance, as both machines can be designed with one or two drive motors, with the two-motor drive variant still dominating in pusher centrifuges despite the advantages of single-drive systems. Single-drive systems, with a combined drive and pusher motor, such as the commercial pusher centrifuge shown in Figure 1, allow the reserve capacity available for pushing to be used for accelerating the basket during the startup process, while the reserve capacity available for the startup process can be used for pushing during stationary operation [2]. This allows significant savings to be made in electricity consumption and installed power.

However, the inner workings of the pusher and the screen-scroll centrifuge are very different. Pusher centrifuges usually consist of one to three (usually two) baskets, with a plate at the bottom, which is mounted on a pusher shaft running inside a hollow shaft. The pusher shaft is subjected to an oscillating axial movement so that the so-called pusher plate performs a pushing motion at the bottom of the basket, whereby the solid material is pushed through the basket. Figure 2 shows the operating principle of a pusher centrifuge with one basket [3].

In contrast to this, screen-scroll centrifuges have a single rotating basket, which is usually conical rather than cylindrical. It is also perforated and lined with screens, but inside it, there is a coaxial and co-rotating scroll conveyor that rotates at a slight differential speed to the basket and thus transports the solids out in a controlled way. The differential speed is realized by a gearbox [4].

In both cases, the solids are dewatered during transport through the centrifugal field and can be washed as needed to enhance product quality. Similarly, the solids are discharged continuously in both centrifuges.

Thus, the fundamental difference between these two types of centrifuges is the method of solids transport.

In fact, all machine and process specifics can ultimately be traced back to the solids transport and the associated differences in the structure of the filter cake. This is explained in more detail in the following two sections.

Feeding conditions

In both types of centrifuge, the product to be processed is fed into the machine centrally via a rotating feeding system. The product is pre-accelerated before it hits the screen, which retains the solids while allowing the liquid (filtrate), to pass through.

Pusher centrifuge. In the pusher centrifuge, a ring of solids (cake ring) is formed, which is pushed in the direction of the discharge by the pusher plate. The empty space that is left when the pusher bottom is retracted is again filled with new product, allowing a new cake ring to form that pushes the previous one onwards during the forward motion (Figure 2). To provide continuous transport of the product, the pusher centrifuge requires a constant supply of product.

Certain minimum requirements must be met so that the cake ring is suitable for pushing. First, some preliminary dewatering is necessary so that the cake is not too wet and the next cake ring can be pushed forward. If the cake moisture content was too high, the cake would splash forward, causing channeling and vibration in the machine. The speed of preliminary dewatering depends on the particle properties, such as shape and size, as



FIGURE 3. This cross sectional view shows the various components of a screen-scroll centrifuge

well as on the properties of the liquid, especially viscosity. Basically, the smaller the particles and the higher the viscosity, the higher the filtration resistance. High filtration resistance calls for slow pre-dewatering and, therefore, limited machine capacity.

Second, the solids must be able to form a solid cake. Solids that are compressible, fibrous or unstable under pressure often do not meet the criteria, so they cannot be processed at all or only in a special version of the pusher centrifuge.

Screen-scroll centrifuge. Looking at the screen-scroll centrifuge, the situation in the feed area is completely different. A filter cake is also formed, but it slides in the direction of the solids discharge right from the start due to the conical shape of the basket. The result is that no cake ring in the proper meaning of the term is formed. Usually the scroll in the feed area initially acts as a brake to prevent solids from sliding down uncontrollably. This results in a significantly lower cake height, and the conditions for transporting the filter cake, such as adding further suspension and pre-dewatering the cake, are no longer needed.

In practice, this means that screen-scroll centrifuges can run with higher liquid quantities and higher viscosities, and also that even strong fluctuations in the centrifuge feed, up to and including interruptions in the

feed, can be tolerated. Solids that are compressible, fibrous or unstable under pressure are also easier to process.

All in all, the feed conditions for pusher centrifuges are more demanding than for a screen-scroll centrifuge, and even technical innovations, such as the prefiltration stages [5], are not always able to completely eliminate this difference.

Cakes, moisture & washing

The previous section showed that the structure of the filter cake in the two types of machines is very different. But what role does this different structure play in the quality of the solids at the discharge?

Compact, relatively high cake rings are formed in the pusher centrifuge that are pushed through the machine by newly forming cake rings. In the screen-scroll centrifuge, a compact, uniform cake covering is only formed in absolutely exceptional cases due to the interaction of sliding and conveying. Viewed in cross-section, its filter cake has a roughly triangular profile (Figure 3), while the one from the pusher centrifuge has a roughly rectangular profile (Figure 2). In addition, the cake height is significantly lower with the screen-scroll centrifuge than with the pusher centrifuge, as mentioned before.

Dewatering. It not only takes increased centrifugal acceleration but, above all, time to dewater the solid material. In its simplified form, this residence time is calculated from the cake volume in the machine divided by the solids volume flow to the machine. Since the filter cake in the screen-scroll centrifuge has a much lower cake height than in the pusher centrifuge, the overall cake volume is smaller and thus the residence time is much shorter. While it is not uncommon for pusher centrifuges to have a residence time of 20–40 s, it is more common for screen-scroll centrifuges to have a residence time of 2–6 s. This effect is weakened by the fact that a lower cake height has a positive effect on the dewatering behavior, because

the liquid in the upper layers of the cake only has to travel a short distance to be removed by centrifugal force. However, it remains to be said that, all other physical conditions being equal, better dewatering can be achieved on pusher centrifuges than on the screen-scroll centrifuge. To compensate for this effect, screen-scroll centrifuges are usually operated at higher speed than pusher centrifuges.

Nevertheless, it should be noted at this point that the remaining residence time will of course no longer improve the residual moisture, if the minimum residual moisture of a product is reached after only six seconds at a certain centrifugal acceleration, and thus in special cases, the residual moisture that can be achieved with the two technologies may be the same. This is often the case with very coarse particles, which are easy to dewater.

Another special case in which the above statement does not apply is in applications involving sticky solids or solids with liquid inclusions. The scroll conveyor of the screen-scroll centrifuge breaks up such structures to a greater extent, which can sometimes result in lower residual moisture than expected in screen-scroll centrifuges.

Washing. The second common quality criterion for solids discharge is product purity. This can be influenced by cake washing, because the aim of cake washing is to wash residues of mother liquor or other impurities out of the solids as efficiently as possible. To make this possible, the filter cake must be penetrated as completely and uniformly as possible by a washing liquid. Since liquid is known to follow the path of least resistance, it is forced to flow through the thinner areas of the cake in the screen-scroll centrifuge, whereas there is less flow through the thicker side of the cake (Figure 3). Accordingly, the cake is not washed very thoroughly on the thicker side — if at all — because there is very little or no contact with the washing liquid.

Compared to the pusher centrifuge, which has a mostly flat cake, the

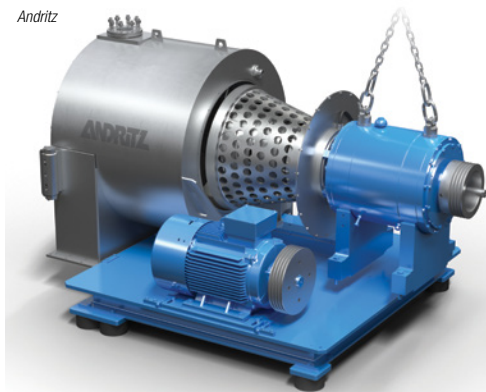


FIGURE 4. The cartridge design enables faster cartridge change, and thus simplifies maintenance

same amount of wash water achieves much higher washing efficiencies.

However, the advantages of washing in the pusher centrifuge go even further. As a rule, there is an optimum point combining washing efficiency and residual moisture. Due to the design, the washing positions can also be adjusted in pusher centrifuges already installed so that they can be set to the optimum. Screen-scroll centrifuges

require washing through an opening in the scroll, and in a machine already in operation this opening can only be moved by using a new scroll.

Filtrate quality

In many applications, the quality of the filtrate is also important. A key factor here is the proportion of solids in the filtrate. The solids usually consist of the fine fraction. In order to keep this low, two measures can be implemented within the machine.

First of all, particle breakage should be kept as low as possible. If there are fewer fines, less solid matter can pass through to the filtrate. And secondly, the filter cake should be as compact as possible, as this prevents the fine fraction from finding its way into the filtrate.

When it comes to particle breakage, the feeding system is of central importance because uneven ac-

celeration of the suspension leads to particle breakage and wear on the machine. It is often argued that the screen-scroll centrifuge of the same dimension produces less particle breakage in the feeding zone because it is fed to a smaller diameter and therefore accelerates to a lower peripheral speed. On closer inspection, however, this is not the case as, on the one hand, there is less time for acceleration and, on the other hand, the screen-scroll centrifuge is usually operated at a higher speed. Hence, pusher and screen centrifuges do not differ significantly in terms of particle breakage in the feed zone, and the efficiency of the feeding systems is more dependent on the different systems used by the individual suppliers.

Particle breakage can also occur during transport of the solids within the basket. In pusher centrifuges, the filter cake is pushed forward by the next filter cake, with the result that particle breakage during transport

is very low, often even negligible. In the screen-scroll centrifuge, it is not possible to prevent a certain fraction of the particles from entering the gap between the scroll and the screen and being crushed. This effect can be mitigated by specifically reducing the gap between scroll and screen [6], but it cannot be eliminated. Another area of particle breakage is the solids discharge, but this is irrelevant to solids loss and therefore will not be discussed here.

As already mentioned above, significantly thicker and largely compact cake layers are created in pusher centrifuges. This results in less fine particles passing through, as the filter cake already formed retains the fine particles. With the screen-scroll centrifuge, the filter cake immediately slides out of the feeding zone, with the result that a thinner cake is formed, whereby more fines find their way into the filtrate. In a way, the disadvantage of the pusher centrifuge for highly viscous and compressible solids turns into an advantage for the clarity of the filtrate here.

Maintenance and operation

The operating conditions described above indicate that in some cases both pusher centrifuges and screen-scroll centrifuges can be used. The decision criteria in such cases are ease of maintenance, operational stability and investment costs. The issue of investment costs is complex and can only be seriously considered on a case-by-case basis because one or the other type of centrifuge may have to be oversized in certain applications and thus become unattractive in terms of cost, despite possible advantages in process performance.

As far as operational stability is concerned, both technologies can be run stably in continuous operation. However, stable feed conditions are essential for this purpose in the pusher centrifuge. If these conditions are present, it is in no way inferior to the screen-scroll centrifuge in terms of stability. However, if feeding conditions are not stable or the feeding flow to the machines has to be stopped several times a day, screen-scroll centrifuges have clear

advantages, because they are much more robust in the face of fluctuations upstream.

As far as ease of maintenance is concerned, it is similar to the feeding system. Although it tends to be the case that screen-scroll centrifuges suffer greater wear on the screens and are operated more frequently at high speeds, which leads to more wear, the vibration level is lower compared to the pusher centrifuge, which puts the above effects into perspective. However, the differences overall are minor, and it is the design of the machine and hence the supplier that are important. When selecting a centrifuge in terms of maintenance, it is important to ensure that the screen is easily accessible as it is a common replacement part, and that the entire rotating unit can be removed from the machine in one piece because this is the only way to minimize downtime for major maintenance work. A proven solution for the latter is the so-called cartridge design (Figure 4), which is nowadays available for both pusher centrifuges and screen-scroll centrifuges.

Concluding remarks

In practice, both the pusher and the screen-scroll centrifuge have proven to be efficient solutions for non-compressible or moderately compressible solids with average particle diameters larger than 80 μm . Since the fundamental difference between the two technologies lies in the form of solids transport and the resulting different structure of the filter cake, particular attention must be paid to the advantages and disadvantages arising from this.

Due to the compact and high filter cake, pusher centrifuges score primarily in terms of the quality of the solids and filtrate produced, while screen-scroll centrifuges prove to be more flexible, especially with regard to process stability, due to the low cake heights and continuous movement of the solids. Screen-scroll centrifuges can be run with higher liquid volumes and higher viscosities and can cope better with fluctuations in the feed. Pusher centrifuges can normally achieve better degrees of dewatering at the same physical conditions

if the materials processed are neither compressible, fibrous, nor unstable under pressure. Similarly, due to the nature of cake transport, the intensity of particle breakage in a pusher centrifuge is minimal, while a certain degree of particle breakage cannot be prevented on a screen-scroll centrifuge due to its design. In terms of maintenance, screen-scroll centrifuges suffer greater screen wear but have lower vibration levels, so there are no significant differences. The cartridge design, which is now available for both technologies, simplifies the maintenance on both machines.

Both technologies come with their own advantages and disadvantages, which makes a precise analysis of the specific application and operating situation, as well as the operator's priorities, indispensable. ■

Edited by Gerald Ondrey

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Ethernet-APL: The Future of Field Connectivity

Ethernet Advanced Physical Layer (APL) provides connectivity between field-generated data and enterprise systems. Presented here is information on the design and operation of this rapidly expanding technology

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IN BRIEF

LEGACY TECHNOLOGY
CHALLENGES

STANDARD ETHERNET
LIMITATIONS

FIELD CONNECTIVITY

ETHERNET-APL
TOPOLOGIES

INTEGRATION INTO
HIGHER APPLICATIONS

FUNCTIONAL SAFETY
AND CYBERSECURITY

FEATURES AND
BENEFITS

BASF CASE STUDY

CONCLUDING REMARKS

Process plants today have vast amounts of data available at the field level from smart devices. However, these data are hardly accessible to other levels of the organization because of the different communications technologies between the devices at the field level and the Ethernet architecture at the enterprise level. This lack of data access hinders the implementation of digitalization projects and prevents process plants from achieving the maximum benefits of data-driven approaches, such as the use of digital twins or predictive maintenance models.

Ethernet-APL (Advanced Physical Layer) is overcoming these challenges by providing connectivity between field data and enterprise systems at the speed and bandwidth required for higher level applications. This article explains how Ethernet APL is being used, and details its features and benefits.

Ethernet-APL transmits power and data via a two-wire cable and can achieve data

rates of 10 Mbit/s with long cable lengths. Ethernet-APL complies with intrinsic safety requirements, and functional safety solutions are under development. Depending on the topology design of the network, up to 50 APL devices or even more than 200 APL devices can exist on an Ethernet-APL segment.

The technology was launched at the Achema Pulse Conference (Frankfurt, Germany; www.achema.de) in 2021 [1] and has been tested in a laboratory at BASF (Ludwigshafen, Germany; www.basf.de). Many benefits have been proven during this evaluation. The technology is expected to expand rapidly with many field devices with APL interfaces already available or soon to be available.

Legacy technology challenges

Industrial instrumentation has progressed from the original pneumatic technology to analog devices, and further, to digital technologies, such as HART, Profibus PA or Foundation Fieldbus. Each new technology has offered benefits over the previous generation, but each still has limitations of its own.

The HART protocol is extremely slow. Troubleshooting and parameterization must be performed locally at the device. Wiring is expensive, and the system requires complex protocol conversions for remote access. HART technicians are required to scale measurements manually during initial device setup, as well as for device replacement. This technology is primarily used for parameterization and troubleshooting and very rarely for process control.

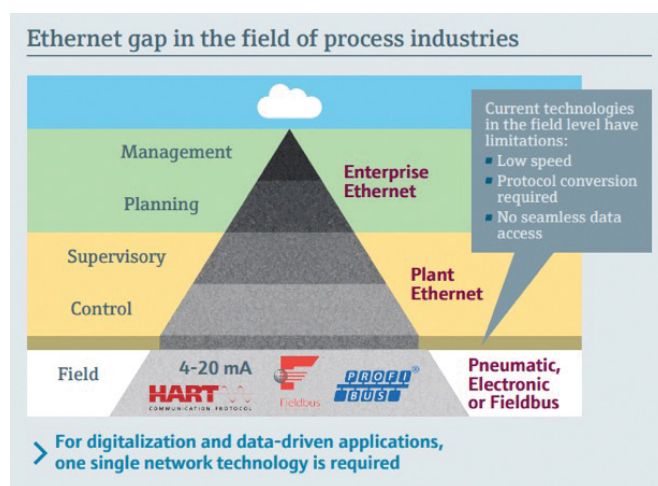


FIGURE 1. An Ethernet “gap” exists at the field-device level

Fieldbus technologies also have a slow data-transfer rate, although it is faster than the HART protocol. However, fieldbus systems are complex in terms of their protocol conversions for remote access, engineering of segments, and troubleshooting. There is some industry resistance to widespread adoption of fieldbus technology due to the complexity associated with its use.

Existing industrial architecture has an electronic or fieldbus layer for field devices, a plant Ethernet network for supervisory and control layers, and an enterprise Ethernet for management and planning. However, to enable the seamless data access across all layers, a single network technology is required. Making vast quantities of data available in real time for optimization and analytical models, while meeting the requirements of the harsh environments in process plants, has been one of the primary drivers leading to the development of Ethernet-APL. (Figure 1).

Standard Ethernet limitations

Standard Ethernet seems to offer many of the features needed for the next generation of industrial field instrumentation. However, there are some drawbacks that make it impossible to implement directly into industrial settings. For example, 100BASE-TX Ethernet has a data rate of 100 Mbit/s full duplex, but cable lengths are limited to 100 m.

Standard Ethernet uses CAT5/6 cables that have four internal wires. This is incompatible with industrial installations, which require a two-wire solution for field instrumentation. It is vital for an industrial Ethernet solution to integrate with the existing two-wire infrastructure to prevent the need for rewiring whole plants, which would not be financially justifiable.

Many field instruments are loop-powered, meaning that they receive the power supply from the same pair of wires that transmits their data. Standard Ethernet is not designed to supply power at this scale, and therefore cannot be used on many field instrument installations.

One of the most critical features of industrial field instrumentation in process plants is compliance to in-

Ethernet-APL topologies

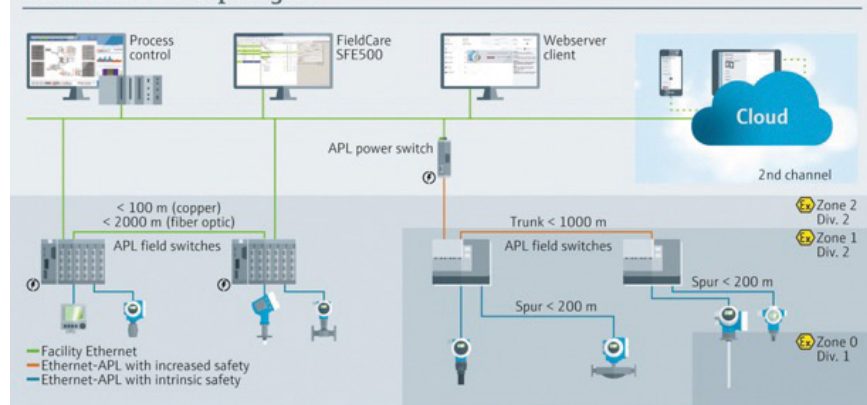


FIGURE 2. Several examples of potential network topologies are possible with Ethernet-APL

trinsic safety requirements. Devices, switches, wiring and terminals found in hazardous areas must be certified as explosion proof or non-sparking depending on the area classification. Standard Ethernet does not meet these intrinsic-safety requirements for industrial applications.

Ethernet-APL is designed to overcome these limitations without losing the benefits of Ethernet technology for industrial use.

Field connectivity

Major user organizations and leading manufacturers worked together over the last years to develop an Advanced Physical Layer for Ethernet that meets the requirements of process plants. The requirements for this new technology were aligned with the NAMUR organization (User Association for Automation Technology in the Process Industries; Leverkusen, Germany; namur.net) and noted in an official NAMUR recommendation [2]. The following standards and guidelines are the most important documents in the context of Ethernet-APL:

IEEE 802.3cg-2019. This new IEEE standard 10BASE-T1L defines the full duplex 10 Mbit/s data transmission via a two-wire cable for long cable runs. It is mainly relevant for the PHYs (the PHY layer defines the physical and electrical characteristics), which are integrated in the APL devices.

IEC TS 60079-47. This technical specification for a two-wire, intrinsically safe Ethernet ensures the installation of two-wire Ethernet devices

in hazardous areas. The concept is derived from the well-known FISCO (Fieldbus Intrinsically Safe Concept) and provides a simple installation without Ex calculations.

APL Port Profiles. This specification defines the power supply via the same two-wire cable with different power profiles. In addition, the preferred cables and connection technology is defined.

APL Engineering Guideline. This user-centric document supports end users during planning, installing and commissioning of APL networks. It provides many useful information in terms of topologies, shielding, cables and so on.










APL Conformance Tests. Via these mandatory conformance tests, it is ensured that APL components are interoperable with each other.

Ethernet-APL topologies

Ethernet-APL can be designed using different topologies to match the requirements of each process plant. "Star" topologies suit plants with a compact layout, while "trunk-and-spur" topologies are similar to fieldbus architectures (Figure 2). Depending on the switch variant, it is possible to mount APL field switches in Zone 2 or Zone 1 areas and to connect APL field devices in different Ex zones, including intrinsic safety (Ex ia).

Star topologies require externally powered APL field switches. These switches supply power to each APL field device connected on the spur line in a point-to-point configuration. Several APL field switches can be

Technologies for the Field of Process Plants

Attribute	4-20mA HART	Fieldbus	Ethernet 100BASE-TX	Ethernet-APL 10BASE-T1L
Single Pair Cable 	✓	✓	✗	✓
Data rate 	1.2 kbit/s half duplex	31.25 kbit/s half duplex	100 Mbit/s full duplex	10 Mbit/s full duplex
Reference Cable 	n/a	Type 'A'	CAT 5 / 6	Type 'A'
Trunk Length 	n/a	typ. 700 m	100 m	1000 m
Spur Length 	n/a	120 m	n/a	200 m
Screw/Spring terminals 	✓	✓	(✓)	✓
Polarity independence 	✗	✓	n/a	✓
Intrinsic safety option 	✓	✓	(✓)	✓
One network technology from field to enterprise 	✗	✗	✓	✓

➤ Ethernet-APL combines benefits of simple and robust 2-wire technology with benefits of Ethernet, enabling top-performance and seamless data access in the field of process plants.

FIGURE 3. The chart shows a comparison of field-level technologies in process plants

connected in line or in a ring formation using copper cables or fiber-optic lines.

Trunk-and-spur topologies require an additional APL power switch, which supplies power from the central control room to the field via a powered trunk line. Both APL field switches and APL field devices are powered via this APL trunk. No other field-level power supply is needed.

There is no general rule about which topology shall be preferred. It always depends on the plant design, communication requirements and the environment. In general, the star topology provides more flexibility in terms of redundancy and number of devices per segment. The trunk-and-spur topology might be more relevant if additional power supply in the field requires a lot of effort.

Ethernet-APL offers a path for migrating a brownfield plant to this new technology. Power conditioners, junction boxes and field barriers must be replaced with APL switches. Any existing cable that does not meet the specifications for Ethernet-APL will have to be replaced as well. The well-known Fieldbus Type A cables, which meet the required APL cable characteristics, are the preferred cable type for Ethernet-APL installations. Specific SPE cables for 10BASE-T1L are also suitable.

APL switch vendors are providing the possibility to connect devices using either Profibus PA or Profinet-APL at the same APL field switch. This means that the Ethernet-APL technology can be installed on site even if some instruments are not yet available with an APL interface.

Integration into higher applications

Ethernet-APL is a new physical layer for the field level connectivity. According to the ISO OSI model, the upper layers are independent of this physical layer, which means that any industrial Ethernet protocol can be implemented on top of Ethernet-APL. This includes Profinet, EtherNet/IP or Modbus TCP. These protocols and their functionalities are important for upper-layer integrations.

Profinet. Profinet is a well-established industrial Ethernet protocol used in many industries already. In combination with Ethernet-APL, Profinet will also fully enter the process industries. The GSD (general station description) file is the Profinet device driver that is used for the integration to distributed control system (DCS). This file is stored on each device, which makes it easy to integrate new devices onto the network. Profinet PA Profile 4 offers additional benefits, such as harmonized inte-



FIGURE 4. The BASF APL evaluation laboratory is shown here

gration and diagnostic messaging. It supports vendor-independent device exchange because parameters are automatically downloaded after exchange without any other system adaptations.

Profinet features like S2 System Redundancy and the Media Redundancy Protocol (MRP) ensure a very high plant availability. This is because the system can cope with both cable failures and controller failures without interruption.

All process variables of a device are available via Profinet in digital form and without conversion losses.

Parameterization, troubleshooting, asset management. These use cases are possible remotely via the network and in parallel to the process control system because information is available at a much higher speed and performance using Ethernet-APL. This means that maintenance personnel can troubleshoot field devices remotely and efficiently by accessing the cause and remedy information for the device. They can also troubleshoot the Ethernet network itself by accessing the frames and packages information without the use of oscilloscopes.

Cloud / IIoT / data-driven applications. An edge device on the facility Ethernet provides an interface to the cloud. This means that field data can be accessed directly by higher-level applications without passing through via a process control system. This setup fulfills concepts like NAMUR Open Architecture (NOA) [3, 4] and related use cases. Edge devices make high volumes of data available in real-time. The technology opens the door for the implementa-

tion of digital twins for equipment monitoring and optimization.

Functional safety and cybersecurity

Safety infrastructure is normally built separately to process control infrastructure. This physical separation increases diversity and independence, which improves safety system availabil-

ity. Safety applications are traditionally equipped with 4–20-mA technology. However, the bandwidth and reliability of Ethernet-APL is creating an opportunity to unify the infrastructure for safety and process control applications, while still meeting the most stringent safety standards. The next logical step is to enable the use of Ethernet-APL in safety applications. There is no limitation to the use of Ethernet-APL for safety applications. The relevant adaptations are mainly on the level of Ethernet protocols.

In the context of Profinet as an industrial Ethernet protocol over Ethernet-APL, PROFIsafe is already available as an additional layer that acts according to the black channel principle. PROFIsafe is a well-established technology that has been used in factory automation for many years. This means Ethernet-APL, in combination with Profinet and its black channel layer PROFIsafe, will be the solutions to bring digital communication even into functional safety applications.

Connecting field devices to the Ethernet network introduces security concerns. There are three areas where security must be taken into account:

- At the device
- At the point of integration to the Ethernet network
- During development

IEC 62443 is the standard governing cybersecurity of industrial automation and control systems. Manufacturers must certify their development lifecycle against this standard [5]. As a further safeguard, organizations belonging to bodies

like computer emergency response teams (CERT) and VDE (Association for Electronic, Electrical and Information Technologies) vulnerability management show that they have systems in place to manage issues that may arise.

At the device level, security is affected at different touchpoints. Firmware update files must be certified as authentic before loading on a device. Authentication and authorization prevent unauthorized access to field devices. Security is a major area of focus for the industry and continues to receive significant investment for future developments.

Features and benefits

Implementing Ethernet-APL is cost effective at each lifecycle stage of a plant. During engineering, APL components might be more expensive, but the complete network infrastructure, the absence of EX-calculations and the fully extendable architecture speed up the engineering process and reduce costs. Installation is error-free and the commissioning stage benefits from fast and remote access for parameterization. This means shorter commissioning times and earlier startup of production. During operation and maintenance, the availability of data enables improved optimization and predictive maintenance.

Ethernet-APL overcomes the limitations of current field level technologies. Ethernet-APL with 10 Mbit/s is 300 times faster than fieldbus technology and even 8,000 times faster than the HART protocol. This speed offers significant benefits during commissioning, operation, and maintenance. A parameter report, for example, can be created within seconds — even remotely, instead of within several minutes — locally at the device.

Speed is not the only advantage of Ethernet-APL. The number of devices per loop is significantly increased. Using a trunk-and-spur topology, up to 50 field devices can be connected to an Ethernet-APL segment. This is a substantial improvement on the 16-device limit for an equivalent Foundation Fieldbus seg-

ment. If you adopt a star topology, you can connect several APL field switches in line and add APL devices up to the limit of a controller. This limit can be further extended by adding another Ethernet interface within the controller.

Ethernet-APL is based on the Fieldbus Intrinsically Safe Concept (FISCO) for two-wire fieldbus solutions, which is already known in process plants. For Ethernet-APL, the same electrical parameters are used and specified in 2-WISE (two-wire intrinsically safe Ethernet). In this way, it does not require any Ex calculations, which significantly reduces the engineering effort when implementing intrinsic safe solutions.

The volume and speed of data transfer available using Ethernet-APL is making possible some higher-level applications that the industry has been demanding for some time. Condition monitoring and predictive maintenance are prime examples where the comprehensive data available from smart devices can be monitored, analyzed and used to determine equipment health. Predictive maintenance techniques enable users to identify issues before they affect device performance so that equipment can be repaired before it has a negative impact on production (Figure 3).

BASF case study

Historically, new product development happened in secret and with a small group of researchers and developers. However, a modern approach includes pilot customers, product managers, market specialists and salespeople. It is with this approach in mind that BASF implemented an APL laboratory to participate in the development of Ethernet-APL. This APL evaluation laboratory is led by the electrical, instrumentation and automation specialists Mathias Koch and Philip Kling, under the supervision of one of the authors (Niedermayer).

BASF started the digital communication journey for field instrumentation in 2005, with Foundation Fieldbus and Profibus PA. But it was only in 2016 that Ethernet was first proposed as a realistic alternative for

digital field connectivity through the development of Ethernet-APL. By 2019, BASF had established a test laboratory for Ethernet-APL using prototype equipment from several vendors (Figure 4). The purpose of the laboratory was to evaluate Ethernet-APL technology for communication between distributed control systems and field transmitters and valves. These tests were very successful and many benefits with Ethernet-based communication could be identified.

Laboratory tests show that Ethernet-APL offers substantial improvements compared to analog technology and Profibus PA or Foundation Fieldbus. It is possible to upload and download sensor information in a variety of formats, including PDF, with a speed which is 300 times greater than what BASF could achieve with fieldbus technologies.

Using the two-wire technology of Ethernet-APL simplifies installation and maintenance activities for field technicians. There is no difference between connecting an analog transmitter and an Ethernet-APL device. Polarity is irrelevant, so the wires can be connected to either terminal without affecting the reading. Motor controllers and frequency converters can also connect to the same (or to a separate Ethernet ring), meaning that all instrument and electrical devices use the same network technology.

Profinet as the industrial Ethernet protocol over Ethernet-APL, including PA Profile 4, offers many advantages to fulfill the requirements of standardization and high availability.

Changing a faulty device on an Ethernet-APL network with Profinet protocol is simply a matter of disconnecting the old device and connecting the new device. The DCS will write the configuration to the device, allowing it to communicate with the DCS directly after booting up. This even works for a device exchange across vendors.

Profinet systems automatically compensate for wire breaks using media redundancy. If a wire breaks in the field, the device will still have a path to transfer the information to the DCS. Controller redundancy is

also built into the Profinet solution. If a controller goes down, the redundancy partner will take over and devices will automatically communicate with the alternate controller. This feature satisfies the high availability requirement of process plants.

Several types of APL field switches were tested in the BASF laboratory leading to some recommendations to vendors. For example, proxies within the APL field switches allow for the connection of PROFIBUS PA devices to the switch, which makes the transition to Ethernet-APL even easier.

BASF is enthusiastic about the capability that Ethernet-APL offers for predictive maintenance. Fast data transfer means that more information can be processed by higher-level applications to analyze equipment health and identify issues before they cause a failure. Edge devices connect to an Ethernet-APL ring and transfer data directly to the cloud. This means that field data becomes almost instantaneously visible from anywhere in the world.

Future developments for Ethernet-APL will expand the use of this technology into functional safety applications. There are substantial benefits to be gained from this approach, including the single-network technology, increased flexibility in plant design, and lower inventory requirements, because the same device could be used for safety and non-safety functions. BASF is already experiencing the advantages of digital measurement, like increased output and product quality, increased maintenance efficiency due to detailed diagnostic information, and increased plant availability. The organization is working with vendors to unlock the benefits of Ethernet-APL for functional safety, too [6].

Concluding remarks

Ethernet-APL is a rapidly expanding new technology that will shape the future of field data architecture. The high speed and bandwidth offered by Ethernet-APL enables digitalization initiatives like digital twins and predictive maintenance. The first APL devices are already available, and further APL devices for other measurements including flow, level,

pressure and temperature, will be available this year. This means that projects using Ethernet-APL can be realized now.

Security for Ethernet-APL systems and devices will also continue to expand in future developments. Standards are regularly being updated to reflect new threats and to address gaps in the technology. As such, vendors will continuously be adding new security features to their devices and solutions over time.

Functional safety solutions are also under development, so that Ethernet-APL devices can be used for either safety or non-safety applications. This has several advantages for the industry, including the simplification of field networks into a single layer and the reduction in spares-holding requirements.

The simplicity of installation and the benefits of data integration from the field to the enterprise level makes Ethernet-APL a key technology for the future of the industry. ■

Edited by Scott Jenkins

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Magnetic-Drive Positive-Displacement Pumps for Chemical Processing Applications

Advances in sliding-vane and internal-gear seal-less pump technologies can provide many benefits when compared to centrifugal pumps or more well-known positive-displacement pump options

**Geoff VanLeeuwen and
Michael Coburn, PSG**

Facilities in the chemical process industries (CPI) use a wide array of flowing substances that must be processed, stored and transferred during manufacturing activities. The technology tasked with facilitating this liquid movement is the industrial pump. As befits what has grown into a very large global industry, a number of competing technologies are constantly positioning themselves to grab the attention — and capital-investment dollars — of the world's chemical processors.

The oldest of these battles divided the camps into those that favored centrifugal pump technology, which uses velocity, momentum and kinetic energy to transfer the liquid — but only if the pump is operating at or near its best efficiency point (BEP) — and those with an affinity for positive displacement (PD) pump technologies, which capture a fixed volume of liquid and transfer it “like clockwork.” These distinctions have led some to call centrifugal pumps “emotional,” since changes to their liquid and system environment directly influence their operational capabilities, while PD pumps are seen as more “stoic,” with the pump steadfastly achieving peak efficiency at all times, no matter the changes in operating environment.

In recent years, however, the dis-

cussion has begun to revolve around another design distinction: is the best pump — be it PD or centrifugal — for CPI applications sealed or seal-less? This article answers that question while illustrating that seal-less PD pump technologies, including sliding-vane and internal-gear pumps, can ultimately be the better choice for certain applications within the realm of the PD pump universe (Figure 1).

Un-sealing the deal

The difference between sealed and seal-less pump technologies is very simple — sealed pumps use dynamic seals to keep the liquid contained, while seal-less pumps do not require dynamic seals to contain the liquid. Sealed pumps can accommodate a constant bleed of trace fluid across the seal faces (even in double seals), whereas seal-less pumps offer true leak-free operation. Although sealed pumps remain more common, seals are viewed as the weakest link in a pump's operational chain, with some analyses of pumping operations indicating that upwards of 80% of all pump failures may originate at the seal. A quick tour through any CPI facility will support this hypothesis: look for wet baseplates and empty baseplates. Both indicate reduced uptime related to a failure in a sealing device.

Now, this doesn't mean that all of these failures are solely the seal's fault. In fact, there are many operational occurrences — including pulsation, vibration, shaft deflection, dry run, viscosity, temperature and pressure changes and liquid crystallization, to name just a few — that can cause the seal to leak or fail, either of which will put the pump out of service. Regardless, a compelling case is created for seal-less pumps, since using this pumping technology could theoretically significantly reduce seal-related downtime occurrences, ancillary costs

for maintenance and repair and maintenance requirements — some of the major headaches that are inherent in operating a pump.

So, if we can agree that there are compelling reasons to consider incorporating seal-less pumps in a chemical-processing operation, the next question becomes, “Which type of seal-less pump?” Which brings the discussion back to the centrifugal or PD pump conundrum.

There has been recent growth in next-generation seal-less designs that feature a magnetic-drive (mag-drive) coupling that is used to transmit torque to the pump. In these configurations, a magnetic coupling connects the driving shaft to the driven shaft without use of a dynamic seal to keep the pumped liquids contained.

Admittedly, mag-drive seal-less pumps typically have a higher purchase price than basic sealed pumps, but as the seals and accompanying seal-support systems get more complicated (and remain more prone to failure), they get more expensive. For example, a triple-lip seal can cost \$3,000, and if you're repairing or replacing it every 12 to 18 months, that cost will add up, along with the added expense of any maintenance or repair calls. Or, for double mechanical seals that require seal-support systems, the seal-support system adds \$4,000 to \$8,000 itself in purchase cost, plus associated costs for monitoring equipment.

Financial considerations aside, mag-drive seal-less PD pumps outperform their seal-less centrifugal cousins by offering new functionality that is not possible with centrifugal pumps. First, seal-less PD pumps are self-priming and have good suction-lift capabilities, while mag-drive centrifugal pumps, just like sealed centrifugal pumps, rely on an integral reservoir that must be pre-filled before it is turned on. This



FIGURE 1. A sliding-vane pump is a type of seal-less positive-displacement (PD) pump that can offer some operational benefits when compared to centrifugal pumps or more well-known PD pump options

TABLE 1. SAMPLE OPERATING DATA FOR MAG-DRIVE PUMPS

	Sliding vane	Internal gear
Maximum flowrate	520 gal/min (1,968 L/min)	500 gal/min (1,893 L/min)
Maximum pressure	225 psi (15.5 bars)	200 psi (13.8 bars)
Temperature range	–30 to 240°F (–34 to 115°C)	–30 to 500°F (–33 to 260°C)
Viscosity range	0.2 cP to 500 cP	5 cP to 50,000 cP
Solids handling	Suspended	Dispersed
Materials of construction	Ductile/cast iron, stainless steel	Ductile iron, carbon or stainless steel, stainless steel
Reverse operation (bi-directional pumping)	Yes	Yes
Heat jacketing	No	Yes

means that they technically are not self-priming pumps, but pre-primed pumps. Second, seal-less PD pumps allow for bi-directional operation. Simply rotate the pump forward or backwards to achieve line stripping in either direction, saving on fluid waste and improved safety in your facility. Third, seal-less PD pumps are not sensitive to changes in operating environment (liquid or system conditions), unlike centrifugal pumps, which must be tuned to a single BEP or they will react negatively to changes in their environ-

ment. Finally, seal-less PD pumps can run dry for extended periods, process suspended solids, and accommodate systems with zero net positive suction head available (NPSHa), whereas centrifugal pumps struggle in each of these areas.

Assessing the PD options

With seal-less centrifugal pumps removed from the equation, it's time to fully consider the seal-less PD options. The most popular in chemical-processing applications have proven

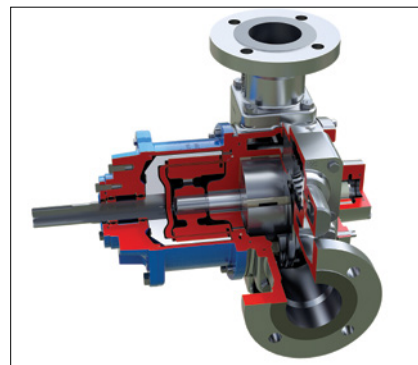


FIGURE 2. Sliding-vane pump technologies are designed to handle a wide range of fluid viscosities and pressures, including media with suspended solids

to be air-operated double-diaphragm (AODD) and peristaltic (hose) pumps. The standout feature of both of these technologies is their ability to pull a perfect vacuum, which thereby enables them to self-prime and achieve good suction lift.

Specifically, AODD pumps are a first-choice seal-less technology for utilitarian pumping applications for a number of reasons: they are inexpensive, very flexible and easy to operate (all you need is an air hose and suction



FIGURE 3. Magnetically driven internal-gear pumps have a simple design with fewer components than other pump types, resulting in streamlined maintenance and reduced downtime

pipe). There are also some shortcomings: their flow and pressure capacities are narrower than some other PD pump technologies; they create pulsation in the liquid path; and because air is expensive, they can be costly to operate, especially when used in continuous-duty applications.

Peristaltic pumps are suitable for handling thick slurries and liquids with large solids. They deliver flowrate consistency despite changes in pressure, but their flowrate range is limited, and pulsating flow can occur, which will make it difficult to dial in a specific flowrate. From a footprint standpoint,

peristaltic pumps are larger than many other technologies, which means they require more operating space. Also, when or if the pump's hoses fail, a catastrophic leak can occur, and hose degradation during operation can compromise the integrity of more sensitive liquids.

On the other hand, two of the lesser-known seal-less PD pump technologies that feature a mag-drive design are sliding-vane and internal-gear pumps. The basic advantages of these mag-drive pumps are that they are electrically driven, so there is no need for compressed air; they have a wide and consistent flowrate range; they create no pulsation in the liquid; they operate well at higher temperatures; they are immune to changes in liquid viscosity or pressure; and they are truly self-priming, meaning they can prime while being fully dry, right out of the box. The following sections take a closer look at the specific advantages of these technologies.

Sliding-vane pumps

Sliding-vane technology (Figure 2) self-compensates for wear, sustain-

ing new performance throughout the pump's operational life. Vane pumps uniquely allow a wide viscosity and pressure range, and are well suited for challenging applications, such as those with suspended solids, varying system pressure, zero NPSHa, liquid-vapor mix and regular dry-run operation.

Reliability. Mag-drive sliding vane technology allows for extended and expected dry-run; high suspended-solids levels (up to 20% in some cases); zero-NPSH-required performance that is ideal for challenging pump inlet conditions, including with liquids featuring up to 20% vapor or air content; and provides uptime without the use of current-monitoring systems.

Functionality. The mag-drive sliding vane technology can achieve suction lift of more than 25 ft (7.6 m) without the need to pre-prime the system; provides bi-directional flow; and can line strip to reduce product waste during or after production runs.

Flexibility. The mag-drive sliding-vane technology provides a wide

operating range that is immune to changing fluid and system conditions. Furthermore, a wide flow and pressure range is achievable, potentially over a smaller equipment model range, optimizing asset flexibility.

Internal-gear pumps

Today's advanced magnetically coupled internal-gear pumps (Figure 3) have a simple design that features only seven main components. The heart of the design is a bearing-to-bearing support system that eliminates leaks. The pump's short spindle also overcomes the challenges that are inherent in pump technologies with longer spindles, namely the impact of overhung loads that can lead to premature wear and failure. Also, unlike centrifugal pumps that rely on cantilevered bearings, internal gear pumps have a symmetrical shaft support, which eliminates shaft deflection during operation, resulting in less maintenance and downtime.

Another standout feature of some magnetically coupled gear pumps is a single-liquid-chamber design that

improves liquid circulation through the coupling area. This results in longer magnet life, lower operating temperatures and more efficient cleaning and flushing processes. By comparison, some gear-pump designs feature a long, tortuous flow path, which can raise the temperature of the liquid as it is being transferred to levels that can compromise magnet life.

So, now the decision involves a choice between PD seal-less mag-drive sliding vane and seal-less mag-drive internal gear pumps. Table 1 provides some representative operating information to compare sliding-vane and internal-gear technologies, which operators can use to select the best option for their specific applications.

Recent advancements in seal-less sliding vane and internal gear pump technology provide new functionality, reliability and flexibility for CPI facilities. These pump designs are leak-free and help eliminate pervasive pain points of legacy technologies that have been used in CPI applications. Now, chemical processors can lever-

age new options that combine leak-free, seal-less performance with the inherent operational advantages that positive-displacement sliding and gear pumps possess. ■

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Steps to Improve Safety Challenges in Hazardous Environments

Compliance with industry- and machinery-specific safety standards and classifications is essential to make the safest possible environment for plant personnel, especially those working in potentially hazardous conditions

Carolyn Reifsteck, Paul Hensy and Chris Liston
SICK, Inc.

Navigating the world of industrial safety standards can feel like being in uncharted waters. In the sea of standards that need to be applied to machinery, systems, processes and facilities, companies can find a beacon of hope by cultivating machine safeguarding solutions to comply with standards (Figure 1). These standards may come from a wide range of global organizations, including the following:

- The International Organization for Standards (ISO; Geneva, Switzerland; www.iso.org)
- The American National Standards Institute (ANSI; New York, N.Y.; www.ansi.org)
- The Occupational Safety and Health Administration (OSHA; Washington, D.C.; www.osha.gov)
- The American Society of Safety Professionals (ASSP; Park Ridge, Ill.; www.assp.org)
- The National Fire Protection Association (NFPA; Quincy, Mass.; www.nfpa.org)

This article describes the experiences of a large global chemical manufacturer with locations around the world that recently navigated the implementation of safety stan-

dards and processes. Compliance with several industry- and machinery-specific safety standards was applied to make the safest possible environment for its employees. Some of these standards are listed in Table 1.

This article outlines a step-by-step overview of how this chemical manufacturer applied these standards to make machinery safer for employees.

1. Conduct a risk assessment

When designing or installing a machine, any potential risks must be assessed, evaluated and mitigated. Where necessary, additional protective measures must be implemented to protect operators and other individuals from any remaining hazards. Sometimes this process begins with an activity called machine safety prioritization, which provides manufacturers with a list that describes which machinery in the facility should be prioritized first for a safety upgrade and which ones can be completed later (Figure 2). Other projects start immediately with a more comprehensive risk assessment, which is a sequence of logical steps based on the systematic analysis and evaluation of risks.

The main goal of a risk assessment is to identify and document hazards for machinery, current manufacturing processes and other elements of the chemical production process. Risk assessments evaluate the tasks performed and help to identify potential hazards, the potential severity of hazards, the frequency of exposure to hazards and the specific strategies that can be implemented to mitigate those hazards and avoid harm to employees and the machinery.

This methodology will identify the potential hazards associated with a

machine or group of machines and quantify the associated risk via the following measures:

- Identifying hazards during setup, operation, maintenance and cleaning
- Establishing minimum performance requirements for the safety-related parts of the control system
- Evaluating existing risk-reduction measures and providing recommendations for improvement

Although the many prerequisites for building safe machines and systems are diverse, all risks must be identified. Then, appropriate measures for minimizing risk need to be identified and their potential effectiveness at reducing risk defined.

A risk assessment enables manufacturers to identify gaps in safety compliance to begin the work to put together a plan to improve upon these gaps. After this large chemical manufacturer completed the risk-assessment process, discussions were commenced to develop a risk-mitigation strategy to bring the equipment into compliance with the applicable standards for the industry.

2. Craft a safety concept plan

Within this global chemical manufacturer's numerous facilities around the world, people are constantly interacting with machines. The inherent hazards within the chemical process industries (CPI) make it essential that the employer properly address those concerns to provide a safe work environment for its employees, so it was an essential priority to raise the level of safety and awareness within its facilities.

The ultimate risk-mitigation strategy is designed according to the results of the risk assessment. If necessary, risk-reduction activities can follow a risk assessment. Risk reduction can include the completion



FIGURE 1. The vast array of equipment types and materials handled mean that chemical manufacturing facilities must comply with a wide range of industrial standards to ensure the safety of employees, equipment and the environment



FIGURE 2. Machinery safety prioritization is often the first activity in the risk assessment process. It helps plants to determine which pieces of machinery are in most critical need of safety upgrades

of a safety concept or a functional-safety design of the control systems, as well as engineering the design of the suitable protective measures.

The safety standard level that the corporation required was identified as Performance Level d (PLd). A performance level is a value used to define the ability of safety-related parts of control systems to perform a safety function under foreseeable conditions. The required performance level is used to achieve the required risk reduction for each safety function. The performance level of safety-related parts of a control sys-

tem must be equal to or higher than the required performance level. Performance levels range from a to e, and the Performance Level Requirement (PLr) is based on three parameters: severity of injury, frequency and/or exposure to hazard, and possibility to avoid hazard or limit harm.

With this global chemical manufacturer, the ISO EN13849-1 standard (see Table 1) was referenced to determine the necessary performance level to reduce risk on machinery in its facility. The company determined that PLd was the best option for its processes. In some cases, this performance level is higher than required, but the company believed that setting this requirement at PLd would provide a distinct advantage to protecting its employees while meeting the core values of the company. The next step involved determining the most efficient, optimal way to incorporate a compliant safety solution into the company's complex applications. Safety is vitally important, but it is also critical to not unnecessarily hinder processes, productivity



FIGURE 3. Plants may include a blend of general-purpose and customized components, so companies must seek differentiated solutions to establish an overarching safety plan

and uptime.

Many of the control components and devices at the manufacturer's facilities are general-purpose, and therefore must be tailored for use in a Class 1, Div. 2 environment (for instance, installed into a purged cabinet or an explosion-proof enclosure). Other times, areas of the facility were unclassified to install certain components. Applying the correct products to meet the appropriate standards was critical, especially for a global organization with similar machines located in different facilities all over the world.

TABLE 1. A SUMMARY OF SELECTED INDUSTRIAL SAFETY STANDARDS

Standard	Date of issue	Title/reference	Typical application
ISO 13849-1	2015	2015 Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design	Functional safety standard that provides guidance on Performance Levels
ISO 13849-2	2012	2012 Safety of machinery – Safety-related parts of control systems – Part 2: Validation	Functional safety standard that provides guidance on validation processes
ANSI B11.0	2020	2020 Safety of machinery – General requirements and risk assessment	Risk-assessment standard that gives guidance on the process and what hazards to look for
ANSI/ISO 12100	2012	2012 Safety of machinery – General principles for design – Risk assessment and risk reduction	E.U. risk-assessment standard, which is harmonized with ANSI B11.0
OSHA 29, CFR §1910.212	Not applicable	General requirements for all machines	Provides guidance on machinery-guarding requirements
OSHA 29, CFR §1910.147	Not applicable	Control of hazardous energy – lockout/tagout (LOTO)	Guidance on LOTO on general machinery
ANSI/ASSE Z244.1	2016	2016 Control of hazardous energy – lockout/tagout and alternative measures	More recent guidance and current state of the art on controlling hazardous energy
OSHA 29, CFR §1910.212	Not applicable	Mechanical power-transmission apparatus	Covers machinery-guarding requirements for power-transmission equipment
NFPA 79	2018	2018 Electrical Standard for Industrial Machinery	Guidance on emergency-stop buttons (e-stops), color-coding for pushbuttons, wires, fuses and so on
NFPA 70E	2021	2021 Standard for electrical safety in the workplace	Arc-flash safety guidance
ANSI B11.19	2019	2019 Performance Requirements for Risk Reduction Measures: Safeguarding and other	Guidance on applying safety devices, guards, resets and so on

Market availability of differentiated solutions and services from third-party providers affords plants several advantages. This enables plants to use numerous products that may not be rated for Class 1, Div. 2, but still meet that certification by using multiple relevant products (Figure 3).

3. Execute machine safeguards

As part of the manufacturer's machine safeguarding solution, the risk-mitigation strategy from the risk assessment (Step 1) and functional safety design of the controls from the safety concept (Step 2) are integrated into the existing equipment to provide that final safe working environment for the plant. Typical safety-critical applications within the chemical industry include screen pack changers, box dumpers, pelletizers, drum lines, shrink wrappers and more. This global chemical manufacturer has all of these types of machinery and plans are in place to apply appropriate safety measures to each of

them. More details about specific safety measures for each equipment category are provided in the following sections.

Screen pack changers. The chemical manufacturer utilized screen pack changers as a part of its process. This machine's main purpose is to remove contaminants from a molten polymer stream. The screen changer consists of a hydraulic cylinder. The cylinder has two sections in the slide plate where the molten polymer flows through. The screen packs on the machine can often be changed during operation without interrupting workflow or reducing production time.

However, there are hazards associated with this machine that needed to be addressed. First, there is the potential for third-degree burns from the molten hot polymer that flows through the machine. Second, it provides a pinch-point hazard with the potential for amputation of limbs. Both of these safety hazards were addressed as

part of the risk mitigation strategy, and the machinery was made safe to meet standards and ensure the safety of workers interacting with this machinery with Class 1, Div. 2 non-contact safety switches and other safety equipment.

Shrink/stretch wrapper. The shrink/stretch wrapper machine consists of a spinning table for finished product on pallets to be wrapped in stretch wrap. There are a number of hazards associated with this type of machine. There is the potential for crushing hazards, pinch-point hazard, and thermal hazard. All of these can lead to broken bones, potential amputation and burns if not addressed properly with safety measures. In order to protect people from these hazards, safety light curtains can be implemented at the entrance and exit of the machine with a request-to-enter locked door. When someone requests to enter, the rotating arm that wraps the product will stop moving when the door is opened.

Filter press. The filter press machine consists of frames of cloth filters that remove solids. The frames become full of the solids and must be manually cleaned. This is a high frequency activity carried out by workers of the global chemical company. Hazards associated with this machinery include crushing hazards, nip-point hazards and impact hazards. These have the potential for amputation or fractures of limbs. These safety hazards will be addressed to ensure the continued safety of workers. This is done by using a moveable interlock guard to provide access to the machine, but still allowing access to the machine when necessary. When someone enters the work area, an output indicates a stop to the



FIGURE 4. Chemical products are loaded onto pallets for shipping. This process carries the risk for personnel injuries and product loss if certain preventative measures are not taken

hydraulic cylinder.

Palletizer. A palletizer machine utilizes electric and pneumatic actions to move and load finished product onto wooden pallets (Figure 4). Similar to other machines, the palletizer has a crushing hazard and a pinch-point hazard, with the potential for broken bones or amputation. Safety measures are planned to prevent these from happening. A robot palletizer is one option to meet safety standards in this application.

Overcoming major challenges

Throughout this ongoing project, there have been a few challenges to overcome. The biggest challenge was that this was a large, ongoing international project with more than one standard that needed to be implemented across several international and U.S. locations. This required an in-depth knowledge on the intent of all the standards, as well as how to properly implement them within these complex applications. This also proved challenging when finding suppliers for the

project. Some manufacturers may certify to FM standards, but not to ATEX standards, meaning that certain items could not necessarily be used globally.

In light of these challenges, the company put together a team with third-party partners that have branches in many countries and include broad expertise and knowledge in the safety industry internationally, with active members on a wide range of safety standardization committees. Another important factor was to develop vendor-agnostic solutions that meet safety standards regardless of what type of equipment has been installed in each facility. A final challenge is ensuring that the proper validation is carried out for the developed risk and safety plans. The validation phase is a comprehensive point-to-point check to ensure everything identified in the risk-mitigation strategy and engineered during the functional safety design of controls has been implemented properly during installation. ■

Edited by Mary Page Bailey

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SICK for over 11 years.

Paul Hensy is a safety solution specialist at SICK, Inc. With over 25 years of experience in the industrial safety industry, Hensy is an experienced safety specialist with a demonstrated history of providing support for process control, engineering, control systems design, business development, and process automation. He has been with



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Chris Liston is a sales manager at SICK, Inc. In this role, he is responsible for working with key international customers and top-tier engineering firms in the process automation space. He has spent most of his career working in the oil-and-gas industry, with the last seven years specifically in process automation. Before joining SICK,

Show Preview



Achema (www.achema.de), the global forum for the chemical engineering and process industries presented by Dechema e.V. (www.dechema.de), is taking place August 22–26 in Frankfurt am Main, Germany. This year's event will feature over 2,000 exhibitors and a comprehensive technical program. The Achema Technical Congress will bring together thought leaders and technology experts to discuss important topics, including: the hydrogen economy; laboratory and analytics advancements; bioprocessing; and much more. This year, several co-located events will expand the breadth of topics, including: Climate-Neutral Chemical Industry 2050; Automation in Dialog; the International Powder and Nanotechnology Forum (IPNF) 2022; and more. This show preview covers a small selection of the products and services of Achema's exhibitors.

Faster battery processing with this powder-dispersion system

BATT-TDS (photo) is a new powder-dispersing system that enables quick mixing of electrode slurries used in the manufacture of lithium-ion batteries. The system is said to reduce the time required for the production of electrode slurries from around 2–6 h to just a few minutes. The system inducts powders dust-free under vacuum into a stream of liquid, thereby creating conditions for optimal dispersion of diverse components in a continuous sequence. Independent control of key parameters, including flow and shear rates, offers a wide process window. Hall 12.0, Stand C68 — *Ystral GmbH, Ballrechten-Dottingen, Germany*
www.ystral.com

New gear pumps and control systems for low-viscosity fluids

The new CoreCommand gear pump is a dosing pump for low-viscosity media in applications where high pressure and a wide temperature range are required. The pump also features a two-stage pump system, which is an unusual feature in typi-

cal gear pumps. The system is suitable for building up a comparatively high pressure with low-viscosity media. The CoreCommand range also includes a pump control system (photo) that can be easily integrated into existing processes. Operation is carried out via a touch-sensitive, 7-in. panel. The control system is housed in a small control cabinet that complies with industrial standards. Due to the control panel's small dimensions, it can be flexibly positioned near the pump. Hall 8.0, Stand F38 — *Witte Pumps & Technology GmbH, Tomesch, Germany*
www.witte-pumps.com

This versatile radar sensor offers safety and security

VegaPuls 6X (photo) is a radar sensor that can measure level in nearly any application. The sensor features a new radar-chip technology and a self-diagnosis system that immediately detects damage or interference, ensuring higher availability and safety. In addition to SIL certification, the matter of cybersecurity is fully taken into account through compliance with security standard IEC 62443-4-2, which specifies the strictest requirements for secure communication and access control. Hall 11.1, Stand C63 — *VEGA Grieshaber KG, Schiltach, Germany*
www.vega.com/radar

Use these plasticizers where durability is a must

Elatur DinCD is a new family of plasticizer for durable products. The new product, a cyclohexanoate, is characterized by a combination of performance properties, such as low-temperature flexibility, and high ultraviolet (UV) resistance, thus contributing significantly to the weather resistance and durability of the products made from it. Due to its low viscosity, Elatur DinCD is easily processed and is suitable for demanding interior and exterior applications, such as textile fabrics, roofing membranes, floor coverings, adhesives and sealants, as well as paints and coatings. The new product is to be manufactured in Marl, Germany. Hall 9.1, Stand D66 — *Evonik Industries AG, Essen, Germany*
www.evonik.com



Ystral



Witte Pumps & Technology



VEGA Grieshaber



ProMinent

Flexible ozone-generation system adapts to fluctuating conditions

Ozone is increasingly being used to eliminate as many pollutants as possible from wastewater. Ozone breaks down trace substances through oxidation or converts them into smaller molecules. They are then easier for micro-organisms to break down in a post-treatment stage or can be removed by means of absorption. Making ozone generation as cost-effective as possible is not easy, because ozone quantities vary greatly due to the huge fluctuations in wastewater quantities and the composition of trace elements. The Dulcozon OZLa is a new ozone system (photo) that can be fitted with up to 16 ozone-generator modules. The modules can be activated and deactivated as required. The amount of ozone produced can therefore be adapted to fluctuations, for example in a clarification plant where varying volumes of wastewater are treated. Hall 8.0, Stand J94 — *ProMinent GmbH, Heidelberg, Germany*
www.prominent.com



VDM Metals International

High-performance alloys for aggressive conditions

This company provides alloys that are designed for the chemical process industries, particularly for high-temperature applications in combination with aggressive corrosive conditions. The new Alloy 699 XA (photo) offers well-balanced metal-dusting resistance, as well as excellent processability and weldability, says the company. The alloy also features favorable thermal-mechanical properties and microstructure stability. It is offered in various product forms, including bars, sheets, plates, wires, welding rods, powder and seamless tubes. Hall 11.1, Stand C59 — *VDM Metals International GmbH, Werdohl, Germany*
www.vdm-metals.com



Swan Analytical Instruments

A wide range of analyzers for continuous water monitoring

This company's analytical instruments (photo) are dedicated to continuous water monitoring and provide a flexible, customized solution to comply with the monitoring needs of a wide range of water-treatment facilities. The range includes single components or complete, panel-mounted instruments with



Flexim

the possibility of individual customization. Rigorous quality controls and tests on an in-house wet bench ensure that strict criteria and standards are met. Hall 11.1, Stand C15 — *Swan Analytical Instruments AG, Hinwil, Switzerland*
www.swaninstruments.ch

A specialized flowmeter for hydrocarbon processing

Designed for use in hydrocarbon processing applications, the Fluxus H831 ultrasonic flowmeter (photo) combines highly precise non-invasive measurement of volume flow and sound speed with advanced calculation features. It is approved for operation in ATEX/IECEx zone 1. Flow measurement is carried out non-intrusively with ultrasonic transducers mounted on the outside of the pipe. Fluxus H831 has two intrinsically safe (Ex-ia) process inputs for connecting pressure and temperature sensors. This allows the transmitter to directly determine API gravity, operational density, density at base conditions and kinematic viscosity. Temperature and pressure compensation allows for precise, standard volume-flow measurement of liquid hydrocarbons. Typical applications for the Fluxus H831 are mass balance, leak and interface detection, product identification in tank farms and oil terminals, quality checks and verification or temporary replacement of stationary measuring devices. Hall 11.1, Stand A16 — *Flexim GmbH, Berlin, Germany*
www.flexim.de

A new line of low-pulsation rotary-piston pumps

This company is launching a new rotary-piston pump that is energy efficient, low in pulsation and hermetically sealed, combining the advantages of other well-known pumping technologies. The pump's design, in which the torque of the outer shaft is transmitted to the pistons by magnets, reduces the pump's maintenance requirements. The new pumps can handle toxic, corrosive or viscous liquids, and are suitable for conveying shear-sensitive and explosive materials. Hall 8.0, Stand C1 — *Paul Bungartz GmbH & Co. KG, Düsseldorf, Germany*
www.bungartz.de



Sulzer



Entex Rust & Mitschke



Fraunhofer IMM3

Process technologies to support circularity

This company will showcase its comprehensive mass-transfer portfolio (photo), process technology solutions, technology licensing and engineering capabilities, placing a particular focus on sustainable production and circular strategies. This will feature a virtual reality (VR) area, where visitors will be able to explore full-scale photorealistic reproductions of real-world processing and manufacturing facilities that leverage the company's equipment. Users will be able to learn how plants can maximize throughput, product quality and energy efficiency, driving their productivity and sustainability. The group will also showcase purification technologies that help to address challenges in plastic recycling and upcycling processes. Hall 4.0, Stand D48 — *Sulzer Ltd., Winterthur, Switzerland*
www.sulzer.com

A new generation of extruders for laboratory use

This company has expanded its range of modular extruders with a new planetary roller extruder for laboratory use, the 30 Series (photo). This unit's size makes it possible to perform series of tests for formulation and product development at laboratory scale. The design features of the new extruder mean that the

advantages of other extruder models — absolute temperature control, capabilities to mix active substances, low-shear thin-layer rolling-out and large surface exchange — can now be applied in material-critical areas in quantities of several hundred grams per hour. Hall 4.0, Stand B8 — *Entex Rust & Mitschke, GmbH, Bochum, Germany*
www.entex.de

This microreactor is designed for electrochemistry scaleup

This organization has developed a flexible and scaleable microreactor for electrochemical conversions (photo). Parallel arranged electrodes, small distance between the electrodes, and their operation under laminar flow conditions lead to homogeneous and beneficial process conditions overcoming limitations linked to conventional electrosyntheses. The reactor concept, based on a plate-stack design approach, allows not only the operation of one electrochemical cell in various configurations, but also the extension to a larger number of cells for scaleup. Now, this expansion approach has been validated through an application of Kolbe electrolysis increasing the number of cells in the stack up to four. Starting from fatty acids obtainable from biomass, Kolbe electrolysis allows the synthesis of valuable chemicals. Envi-

sioned is a further increase up to 20 cells corresponding to a production capacity of about 3 kg/h of production. Hall 9.1, Stand E64 — *Fraunhofer Institute for Microengineering and Microsystems (IMM), Mainz, Germany*

www.imm.fraunhofer.de

This series of explosion-proof pumps has been expanded

This company has expanded its OktaLine range of Roots pumps (photo), which are designed for use in potentially explosive environments or for evacuating explosive gases. Designed in accordance with the ATEX Directive (2014/34/EU1 or 1999/92/EC) with pressure surge resistance of PN 16, they meet the

Pfeiffer Vacuum



highest explosion protection requirements. Zone entrainment of explosive gases is ruled out as a result. Due to the expansion of the series, pumping speeds range from 280 to 8,100 m³/h. Depending on the application, there is a choice between equipment category 2G or 3G. All pumps are suitable for temperature class T3. Installation is possible without flame arresters. This means that the full pumping speed of the pump is effectively available. The pumps are suitable for universal use due to their variable differential-pressure and flexible rotational speed. All pumps can be used at ambient temperatures ranging from -20 to 40°C. Hall 8.0, Stand J37 — *Pfeiffer Vacuum GmbH, Asslar, Germany*

www.pfeiffer-vacuum.com

Expanded flow-chemistry range for a large span of flows

With the recent acquisition of Alconbury Weston Ltd. (AWL), this company has expanded its continuous-processing capabilities and bridged

a crucial gap in flow chemistry. Combining the newly acquired technologies with existing capabilities enables the group to tackle complex processing issues, including continuous reactions, crystallization processes that have a high crystal concentration, and continuous drying and filtration processes at all production scales, from laboratory and research to commercial. The company will be highlighting an engineered facility that demonstrates the working steps from continuous reaction, crystallization, filtration and drying to the mixing process and dosing into the final packaging. Hall 12.0, Stand A21 — *Dec Group SA, Lausanne, Switzerland*

www.dec-group.net

This flexible atomizer simplifies spray-drying operations

The patent-pending Air Bearing Atomizer (ABA; photo, p. 52) provides low-maintenance operation for spray-drying applications. Conceptually, a thin film of pressurized



Dedert International



Bronkhorst High-Tech



Buss-SMS-Canzler

air “levitates” the shaft of the rotary atomizer, yielding a virtually frictionless operation with true alignment while eliminating wear parts. Unlike established air-bearing technology, this new technology’s efficiency and effectiveness is due to a proprietary air distribution mechanism. The system is oil- and contact-free and runs on utility air level, meaning that no lubrication system is necessary. The permanent-magnet-motor technology is 95% efficient with high power levels and high disc-tip speeds. The atomizer has only one moving part, which eliminates premature wear, reduces spare parts and lowers maintenance requirements, such as bearing-changes. In addition, a rotating maintenance stand is provided for ease of servicing and cleaning. The units are available in three sizes to meet a full range of industrial spray-dryer capacities: ABA-25 (25 kW), ABA-100 (100 kW) and ABA-300 (300 kW). Hall 4.0, Stand G3 — *Dedert International A/S, Ballerup, Denmark*
www.dedert.com

Multifunctional flowmeters that are extremely compact

The Flexi-Flow thermal mass flowmeter (photo) combines the advantages of a unique through-chip-sensor with proven bypass technology. The compact meters and controllers are 35% smaller than traditional instruments, making them the smallest on the market for flow ranges up to 20 l_r/min, says the company. The instruments feature very stable flow control, but also very fast control, with settling times smaller than 150 ms. Flexi-Flow instruments have integrated temperature and pressure sensors and an onboard gas database for high accuracy, even at varying process conditions. The instruments are adaptable to many applications due to their wide dynamic flow ranges. The temperature and pressure signals may provide the user with information about the actual process conditions, making the meters capable of multiparameter measurement and control. Hall 11.1, Stand F3 — *Bronkhorst High-Tech BV, Ruurlo, the Netherlands*
www.bronkhorst.com

Continuous monitoring of thin-film evaporators

This company offers predictive maintenance solutions for mechanical seals and bearings on thin-film evaporators (photo, p. 52). The predictive-maintenance platform includes an early warning system to enable optimized availability with minimal downtime. Status information can be transmitted to mobile phones so that personnel can remotely check equipment. Hall 4.0, Stand B24 — *Buss-SMS-Canzler GmbH, Butzbach, Germany*
www.sms-vt.com

Valve actuators for extremely harsh environments

High-performance Tigron valve actuators (photo) meet the requirements of demanding applications, from petro-



leum production, storage and transport to downstream processing. They are ATEX and IECEx certified for the highest gas group IIC T4, which includes hydrogen. Other approvals are also in progress. A wide temperature range from -65 to 75°C, IP68 protection and an extremely resistant powder coating ensure that Tigron devices operate safely and reliably in harsh environments. The smart actuators are available in different sizes and combinations to suit all valve automation tasks, including high-precision operation of control valves and choke valves. Operation via magnetic pen is available for extreme conditions. A commissioning assistant makes setting up easy and safe. Tigron actuators provide non-intrusive setup without requiring additional tools for commissioning. In hard-to-reach locations, or where vibration is a problem, the controls can be mounted separately from the actuator. Hall 8.0, Stand C23 — *AUMA Riester GmbH & Co. KG, Müllheim, Germany*
www.tigron.auma.com



Durable fluoropolymers with a wide processing window

This company's flagship fluoropolymer resins — the Kynar range — are designed for excellent durability and resistance to aggressive chemicals, radiation, sunlight and ultraviolet light. The polyvinylidene difluoride (PVDF) resins are especially suited for the ever-growing semiconductor applications market (photo). With rigid, flexible and highly flexible grades available, Kynar PVDF resins provide a balance of mechanical properties and melt processability for a wide range of process applications. Hall 9.1, Stand A31 — *Arkema S.A., Colombes, France*
www.arkema.com

Single-use separators eliminate cleaning requirements

The kytero single-use pharma separator (photo) provides high separation efficiency, simple and safe handling

GEA Group



and the elimination of costly cleaning procedures. With its maximized separation efficiency, yields up to 98% and gentle product handling, kytero systems enable new ways for processing cell-culture-based fermentations in pilot plants, laboratories and small-scale biopharmaceutical production facilities. As the systems rely on disk separators, the use of filtration is significantly reduced. The kytero 500 was developed for a capacity of



Stöcklin Logistik



Ridart

up to 150 L/h and is thus suitable for laboratories and small batches. For scaleup applications, another model will soon become available, says the manufacturer. The gentle feed system preserves the vitality of shear-sensitive products. With the single-use separators, all product-contacting parts are replaced after use, preventing any cross-contamination without the need for cleaning and sterilization. The frictionless drive system provides 100% biocontainment by eliminating the need for seals or mechanical bearings. Setup and changeover time (only 5 to 10 min for preparation) is minimal. No auxiliary equipment, such as water, buffers or tanks, is required. Hall 4.0, Stand G66 — *GEA Group, Düsseldorf, Germany*
www.gea.com

These battery-operated forklifts are now IECEx-certified

Last December, the Ex forklift series, equipped with LiTex batteries (photo), received the IECEx safety certification for safe operation in

potentially explosive environments, including in gas (Zone 1) and dust atmospheres (Zone 21). Following the 2018 launch of LiTex — the world's first lithium-ion battery for use in Ex-protected environments — this new certification is a key prerequisite for Korean Certification (KC), which is required in Asian markets. The explosion-proof LiTex battery can be charged at any time in the ATEX zone, just like a normal Li-ion battery, which increases efficiency and availability of equipment. In the past, users had to leave the explosion-proof room or even the shop floor to charge the battery. As charging usually takes around 8 h, batteries had to be changed during shift operation in order to continue working. This significant loss of time is eliminated by LiTex's pressurized charger. According to the company, a battery life cycle of at least 5,000 full cycles is guaranteed. Hall 9.1, Stand A59 — *Stöcklin Logistik AG, Laufen, Switzerland*
www.stoecklin.com

An overflow protection valve for underground storage tanks

This company offers a wide range of brass, aluminum and stainless-steel safety valves for use in petrochemicals facilities. The company's Model 442 overflow protection valve (photo, p. 54) is designed to prevent the overfill of underground storage tanks by providing a positive shutoff of product delivery. The shutoff valve is an integral part of the drop tube used for gravity filling. The Model 442 is certified as a two-stage shutoff valve. When the liquid level rises to about 95% of the tank capacity, the valve mechanism is released, closing automatically with the flow. The operator may then stop the filling process and disconnect and drain the delivery hose. As long as the liquid exceeds the 95% level, the valve will close automatically each time delivery is attempted. If the delivery is not stopped and the liquid rises to about 98% of tank capacity, the bypass valve closes completely. No additional liquid can flow into the tank until the level drops below a reset point. Hall 9.0, Stand A30 — *Ridart S.r.l., Gazzada Schianno, Italy*

www.ridart.it



This system can be adapted to count tablets or gummy products

The DMC Series is an automatic tablet/capsule counting machine (photo) that can be equipped with special parts and devices and modified to become a counter for gummy products. By replacing the hopper and tray for the gummy, it is possible to count and fill both conventional tablets and gummy products with a single counting machine. The adaptable gummy-exclusive tray features an embossed stainless-steel surface to improve the flowability

of the gummy product, and a special agitator installed in the hopper helps to loosen any clumped gummy products and separate them one by one. When compared to a typical checkweighing system, a designated counting machine can increase productivity because loss rate is reduced. Hall 3.1, Stand G69 — *Countec Ltd., Gyeonggi-Do, South Korea*

www.countec.com



Crossflow filters ensure high product quality and yield

The Krauss-Maffei dynamic crossflow filter (DCF; photo) is suitable for the clarification of liquids and for concentrating and washing of solids in a broad variety of chemical and biochemical products. Whether the targeted products are solid or liquid, the Krauss-Maffei DCF increases yield and product quality. The filters offer extremely high yields and can process highly concentrated suspensions up to a viscosity of 7,000 mPa.s. Product quality is assured due to the DCF's single-pass filtration concept, short residence times and the elimination of gas contact. Higher permeate flux means that a smaller installed equipment footprint is required. Hall 12.0, Stand C19 — *Andritz Separation GmbH, Graz, Austria*

www.andritz.com/separation

Continuous casting for membranes, films and more

This company offers continuous film-casting systems (photo, p. 57) for the production of membranes, separators, ceramic tapes and optical films. The systems use a stainless-steel belt to transport a layer of liquid product through a series of carefully controlled sections. This involves heat and mass transfer in the evaporation process or a controlled phase-separation process in a precipitation section. Once these processes have

Air Bearing Atomizer

Dedert continues to revolutionize the industry while challenging the competitive market in launching their new patent-pending Air Bearing Atomizer. This technology provides a robust, low maintenance, and trouble-free operation for spray drying applications.

Conceptually, a thin film of pressurized air “levitates” the shaft of the rotary atomizer, yielding a virtually frictionless operation with true alignment while eliminating wear parts. Unlike established air bearing technology, this new technology’s efficiency and effectiveness is found in Dedert’s proprietary design with novel air distribution mechanisms, which allows the following operational advantages:

- **Oil-Free & Contact-Free:** This Atomizer is oil and contact free running on “utility level” air with no lubrication system necessary
- **Simple & Ultra-Sanitary:** The oil-free operation prevents risk of product contamination for food-grade applications while simplifying maintenance and sanitation requirements. All internal parts are FDA compliant, featuring stainless-steel construction and a lightweight Titanium disc.
- **Sustainable & Energy-Efficient:** The permanent magnet motor technology is 95% efficient with the capability to achieve high power levels and high disc-tip speeds, which enhances the sustainability index value and lowers overall CO₂ emissions due to reduced energy consumption.
- **Reliable and Low-Maintenance:** The robust atomizer has only one moving part, which eliminates premature wear-and-tear, reduces spare parts usage, and lowers maintenance requirements such



as bearing-changes. In addition, a rotatable maintenance stand is provided for ease of servicing and cleaning.

The Air Bearing Atomizer comes with a control and monitoring system in an integrated control module for easy on-site setup, complete with a HMI, a PLC and instrumentation for utilities control. A graphical user interface (GUI) provides an intuitive and comprehensive interface of the complete system along with the data recording for all the parameters.

This new product line is available in three (3) sizes to meet the full-range of industrial spray dryer capacities: ABA-25 (25kW), ABA-100 (100kW), and ABA-300 (300kW).

Learn more about the Air Bearing Atomizer at Achema 2022 (Frankfurt, August 22-26), Dedert will be exhibiting in Hall 4.0 at Booth G3!

<https://www.dedert.com>

been completed, the solid formed or transformed product is removed from the belt. At this stage, the product will be either in final or intermediate form; the latter requiring further processing, such as post-drying, leaching or stretching. Key benefits include ultra-efficient continuous production, the ability to cast very thin films to fine tolerances and producing high-quality microporous membranes. A pilot film-casting line with a Venturi dryer module and a conventional impingement-dryer section is available for customer trials at the company's productivity center in Fellbach, Germany. The unit features a winding and unwinding unit and is capable of handling water- or solvent-based casting solutions. Hall 4.0, Stand D4 — *IPCO Germany GmbH, Fellbach, Germany*

www.ipco.com

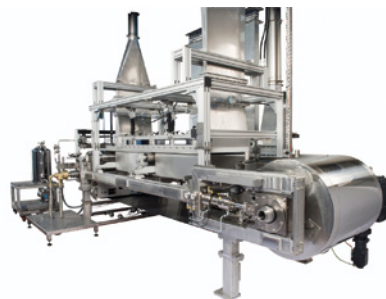
A flexible tablet press for laboratory-scale test runs

The TPR 200 Plus tablet press (photo) offers efficient processing for various granules and pellets. It also fea-

tures a light containment concept with dust-tight machine protection up to Occupational Exposure Band (OEB) 3. Besides the production of small and medium-sized batches, the compact system supports the development of continuous tablet production. When combined with the company's Solidlab 2 Plus system, the TPR 200 Plus is particularly suitable for laboratory-scale test runs and subsequent scaleup. The automatically adjustable powder feeder with automated process-development software allows users to define the optimal parameters for the formulation feed going into the die. The new system also allows users to improve existing processes and increase the product yield and quality in tablet production. Process efficiency benefits from an integrated data-acquisition system, which assesses tablet quality and process stability. Hall 3.1, Stand C71 — *Syntegon Technology GmbH, Crailsheim, Germany*

www.syntegon.com

Mary Page Bailey



IPCO Germany



Syntegon Technology

Europe

special advertising section

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Universal Control Unit for Pumps and Measurement Instruments

OmniControl from Pfeiffer Vacuum can be individually configured and intuitively operated

The OmniControl unit allows the comprehensive control of a complete vacuum system using just one device. It combines the control of the total pressure with the control of the pumps. The unit communicates with products that support the Pfeiffer Vacuum RS-485 protocol (e.g. HiPace, HiScroll, HiLobe, MVP and DigiLine). This makes it possible to exchange and process data between various Pfeiffer Vacuum products without any difficulty and without having to invest in additional devices. Optional gauges from the ActiveLine range (with analog output) can also be connected.

The 3.5 touch screen with an intuitive user interface ensures easy and convenient control of the vacuum system. For example, a button for switching the devices on and off can be added. The total pressure and the pump parameters (RPM, power input etc.) can be displayed at the same time.

The basic version of the OmniControl is available with or without an internal power supply. With the Gauge/IO option, there is no need for a separate vacuum gauge controller. Various inputs and outputs are provided for connecting external components. For example, a valve can be switched according to the pressure level.

With the Data option, the measured values can also be saved as a CSV file on a USB stick or a MicroSD card. The data can then be analyzed and archived. The data items to be saved can be freely defined (total pressures, RPM, error codes etc.)

Pfeiffer Vacuum offers a full range of hybrid and magnetically levitated turbopumps. The product portfolio comprises also backing pumps, leak detectors, components, measurement and analysis



**Easy control of vacuum systems with
OmniControl unit from Pfeiffer Vacuum**

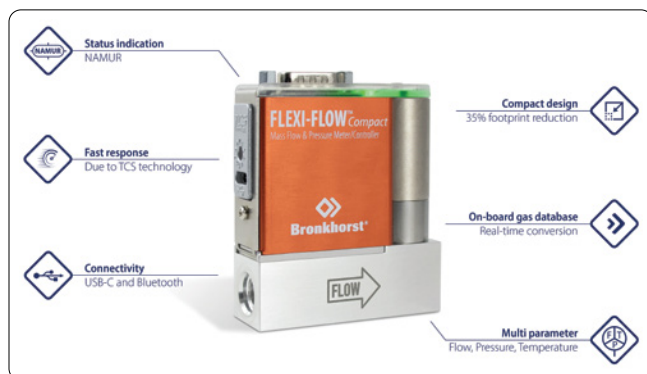
devices, as well as vacuum systems and chambers. The company stands for innovative solutions and high-tech products in the analytical, industrial, research & development, semiconductor and future technologies markets.

www.pfeiffer-vacuum.com

Mass Flow Control #Redefined

Compact Multifunctional Mass Flow Meters/Controllers for Gases

The new FLEXI-FLOW by **Bronkhorst** combines the advantages of a unique through-chip-sensor with proven by-pass technology. The compact thermal mass flow meters and controllers are 35% smaller than traditional instruments, the smallest on the market for flow ranges up to 20 l/min. Due to the new sensor technique, the instruments feature very stable flow control, but also very fast control, with settling times smaller than 150 ms.



FLEXI-FLOW instruments have integrated temperature and pressure sensors and an on-board gas database for highest accuracy, even at varying process conditions. With this new technology, the instruments are adaptable to many applications through their wide dynamic flow ranges (up to 1:1000). The temperature and pressure signals may provide the user with information about the actual pro-

cess conditions. So in fact, FLEXI-FLOW is more than just a flow meter or controller; it's a multi-parameter measurement/control device.

For easy setup and monitoring of the instruments and your process, Bronkhorst introduces a USB-C port, optional Bluetooth communication, and NAMUR status indication by means of coloured LEDs and digital output parameters. FLEXI-FLOW is available in 2 pre-configured models, as a built-to-order version, or as a customised, multi-channel solution, each including free and easy software tools for configuration, and for diagnostics and predictive maintenance.

Top 5 unique features

- 1 Multi-parameter measurement: flow, temperature, and pressure
- 2 Very compact instrument, saving space & weight
- 3 Simple & secure connection through Bluetooth and comprehensive App
- 4 Adaptable to many applications through wide dynamic flow range
- 5 NAMUR status indication keeps you informed about your process

Highlights

- Swift response to setpoint changes
- Stable gas flow control
- Proven bypass technology
- Precise measurement

www.bronkhorst.com

Use Cases around MTP, NOA and Power-to-X

As part of this year's Achema, **Phoenix Contact** will be demonstrating in Hall 11.1 Booth A27 how the company is turning new technologies into practical solutions in cooperation with various partners. There is no question that in the future, plants will be composed of process modules that can be seamlessly integrated into the overall solution using MTPs (Module Type Package). This not only saves time: Modular plants can always be adapted to changing market requirements. A joint use case with X-Visual Technologies GmbH, Semodia GmbH, ABB AG and Wotten Consulting illustrates what a continuous engineering process from process engineering to module orchestration looks like. The example of a trace heating system will also show how services such as temperature control can be encapsulated. Furthermore, Phoenix Contact will demonstrate with Seepex on a Smart Dosing Pump that this can be easily automated by using the MTP Designer from Phoenix Contact as well as providing the operator with different services.



Ready-to-operate control cabinets for power-to-gas applications

Another focus of the trade fair presentation will be the interaction of MTP and NOA (Namur Open Architecture). Using a live demo, visitors can find out how the sensor system of an agitator vessel sends M+O data (Monitoring & Optimization) to the control station via the NOA side channel. The Aucotec Engineering Base platform then displays, among other things, maintenance requirements and changes in the field. One of the great challenges of our time is climate change. If the rise in temperature is to be limited, energy must be generated exclusively from renewable sources. But volatile generators require storage solutions, such as the conversion of solar and wind energy into power-to-gas. On request, Phoenix Contact supplies ready-to-operate control cabinets for corresponding systems. As the centerpiece, the PLCnext controllers installed there not only control hydrogen production. They also monitor the filling levels in the tanks, supply the electrolytes in a controlled manner, control the ventilation as well as the water pre-treatment and implement the electrical load management as well as safety-related applications including emergency shutdown. This use case will also be presented at Achema.

www.phoenixcontact.com/en-us/

World's first smartwatch for Zone 1/21

i.safe MOBILE introduces multifunctional ATEX/IECEx-certified smartwatch IS-SW1.1

The innovation leader **i.safe MOBILE** complements its overall portfolio for explosion-proof mobile devices and solutions with the introduction of the world's first smartwatch for zone 1/21 industry use in the chemical, pharmaceutical, petroleum processing and other demanding branches of industry. With this development, the R&D team of the German-based manufacturer has succeeded, to close a crucial gap in the area of employee safety and organisation. The manufacturer developed and integrated a "personal device" established in everyday life into working areas across industry ATEX/IECEx zones 1/21. The smartwatch can be paired with i.safe MOBILE devices via Bluetooth and functions as a complementary hands-free wrist display, remote SOS button and RFID reader. The IS-SW1.1 can emulate various RFID smartcards for access control systems and simultaneously monitor the user's vital signs pulse and oxygen saturation.

The new smartwatch contributes significantly to the safety of the employees by displaying hands-free important messages, hazard messages and measured values directly on the user's wrist – without picking up the smartphone. In emergency situations, it is possible to make a call directly via the SOS button of the smartwatch on the wrist (connected to the emergency app of the smartphone) - the employee can easily be located via GPS. The monitoring of pulse and oxygen saturation additionally complement the safety concept. Coupled with the push-to-talk-enabled smartphone, users can apply the smartwatch as remote PTT button.

With the integrated RFID chip, the smartwatch can be used very flexible. RFID tags attached to machines or sensors can be read and the associated measured values can be shown directly on the clock display. Due to RFID card emulation, the watch is excellently suited for commercially available access control, time recording and payment function systems based on MIFARE i.e.

www.isafe-mobile.com



Smart process solutions for dewatering and drying

In hall 12.0, booth C19, **ANDRITZ** will be presenting latest insights into its comprehensive portfolio covering the broadest range of technologies and services for mechanical and thermal solid/liquid separation as well as fully integrated systems. From filters and centrifuges to many different types of dryers; all optimized with the most innovative automation solution on the market today – the Metris addIQ control system.

One highlight will be the newly launched ANDRITZ screen scroll centrifuge HX. It can process bulk chemicals, minerals, agrochemicals, and food, even under difficult feeding conditions. It is designed for improved product quality and maintainability. New features include a Gentle Feeder™ feeding system, a modular scroll, and a rotating assembly that can be removed and replaced in one piece (express cartridge). The express cartridge design enables the entire rotating assembly to be replaced without dismantling any process piping, reducing downtime to less than eight hours, even for major maintenance work. Minor maintenance work can be done without removing the cartridge as the scroll and screens are easily accessible and removable. The scroll itself is a modular unit designed specifically for cost efficiency and rapid repairs – worn parts can be replaced separately using standard tools. These new features minimize maintenance costs and maximize uptime.



ANDRITZ screen scroll centrifuge HX

www.andritz.com/separation

Thin Film Evaporator 4.0

24/7 monitoring of mechanical seal

Thin film evaporators, short path evaporators and thin film dryers are rotating equipment widely used in thermal separation. Typical applications among others are the recovery of catalysts, omega-3 enrichment, sewage sludge drying and evaporation of monomers from polymers down to very low concentrations. In such equipment a rotor applies the feed material to the inner surface of the heated shell to a thin layer. From this thin layer the feed evaporates partially. This allows thermal separation of components from the feed or the drying of the feed material.

In many of such processes the equipment is operated under vacuum to reduce the evaporation temperature. Thus, the shaft of the rotor drive needs to be sealed with a mechanical seal to minimise the air intake from the environment. The tightness of the mechanical seal is one of the critical



parameters to keep the vacuum and the process running. Therefore, the three companies **Buss-SMS-Canzler GmbH**, the number one in thin film technology, METAX Kupplungs- und Dichtungstechnik GmbH, specialist in design and manufacturing of mechanical seals, and BestSens AG, specialist with proprietary sensor technology, devel-

oped a mechanical seal equipped with integrated status monitoring. The monitoring delivers data of the mechanical seal operation, which is the base of the decisions for a goal-oriented maintenance. On top of the predictive maintenance, the status monitoring allows the setup of an easy warning system and status information to the mobiles of your staff. All these features improve the safe operation of the mechanical seal and minimise equipment downtime of thin film evaporators.

www.sms-vt.com

Improved customer service with BEUMER Smart Glasses:

The virtual view

If faults and downtimes occur in machines and companies are unable to rectify them as quickly as possible, this can be expensive for them. With the **BEUMER** Smart Glasses, the BEUMER Group has developed a pioneering product that helps users to avoid precisely this quickly and easily: BEUMER Customer Support employees look over the shoulder of the customer's service technician virtually and solve the problem together with him. Remote commissioning is also possible.

The employee at the machine puts on the glasses and starts the BEUMER Support App via voice command. He transmits a service number and a pin code to the hotline, and the connection with image and sound is established securely. The BEUMER technician receives the same image that the customer sees. This means that he can give him instructions directly and display all relevant information in the field of vision. The employee has both hands free to follow the expert's instructions and perform the necessary actions. In this way, faults can be

solved quickly and precisely – at any time. BEUMER experts are available around the clock, seven days a week. Language barriers or a lack of specialist knowledge are therefore no longer relevant when troubleshooting. Based on the recorded images, the experts can better clarify with the operator why the fault occurred in the first place.

Looking into the distance with smart glasses

With the digital solution, customers can not only be helped in case of malfunctions or downtimes of existing plants. Remote maintenance is also possible, in which BEUMER experts connect to the system – regardless of the time or day. This increases the availability of the machines, as no long journeys are required. In addition, there is the option of remote commissioning: The



BEUMER Customer Support sees the same as the carrier on site and can directly specify the correct actions.

Corona pandemic is massively changing the travel behaviour. Due to travel restrictions, the technicians cannot always be on site. Nevertheless, it is important to get new machines up and running quickly. The data goggles allow an overview of the entire system: BEUMER Customer Support sees the same as the wearer on site and can directly prescribe the correct actions. In this way, he guides the user step by step through commissioning. The BEUMER experts can react flexibly with this procedure.

www.beumer.com

On-site calibration services

Maximizing process uptime while reducing risks and safeguarding compliance

A flowmeter that is not measuring properly can cause many problems. For example, in a custody-transfer application, even the smallest error can cost an operator millions of dollars a year. And though calibration may not be the biggest or most important task on the to-do list of a chemical plant, it can have a big effect throughout the plant. Outsourced to experts, calibration positively affects production, compliance and the risk of quality or safety deviations.

Flowmeters are often removed from systems for the purpose of calibration and sent to a calibration laboratory. The commonly held belief is that the necessary calibration

accuracy can be guaranteed only under laboratory conditions. However, this is only partially true. Flowmeters and many other measuring devices can also be calibrated directly on-site. There are several advantages to this:

- Plant availability improves as the device is calibrated nearline or inline.
- Sources of error can be detected and eliminated on-site, while the ability to achieve the same result in a calibration lab is limited. Calibration technicians on-site can detect errors during installation and identify blockages or contamination in the pipes directly in the system.

- Cost savings increase due to the speed of completion, reduced downtime and the elimination of an inventory of replacement parts.
- There is no need to disassemble and ship contaminated devices, contact with hazardous substances can be reduced, and costly decontamination can be avoided.

Calibration requires time. Ideally, calibration runs are part

Endress+Hauser



of scheduled downtime, so manufacturing is not affected. However, experience shows that windows for scheduled downtime get shorter and shorter. Usually, instrumentation is handled last. This is why calibration should always be performed in a time-optimized manner. On-site calibration reduces coordination efforts, eliminating the need to remove and transport an instrument to a calibration facility. While it might take days or weeks for a device to return from a calibration lab, an on-site calibration can be performed within hours.

With in-depth application, metrology and measurement expertise, certified operators, and traceable documentation, Endress+Hauser can maximize the potential of on-site calibration without compromising safety or compliance.

<https://eh.digital/onsite-calibration>



Flexible couplings for every challenge

In nearly a hundred years, the flexible pin couplings N-Eupex have proven to be one of **Flender**'s most successful solutions. For even more reliability and flexibility, innovations were added. Especially in pump applications, the new double-cardanic coupling N-Eupex DKS can be used as a problem solver. It is the shortest double-cardanic coupling on the market. The shortened overall length enables cost-optimized use with a small shaft distance dimension without losing the advantages of a double-cardanic coupling connection. The new N-Eupex ERN is equipped with a torque limiter, which provides even more security in the drivetrain in many applications. The coupling variant allows users to specify a maximum torque so that critical torques for the motor and output machine are not transmitted. Machines and systems are protected from overload and damage.

With the N-Eupex B plus clamping element, Flender introduces a third new coupling that ensures frictionally engaged clamping connections. The plain, cylindrical machine shaft end is connected to the coupling hub via a clamping connection without a feather key and service ability is increased. The new products allow users additional flexibility in their systems without losing the compact design and high load capacity of a pin coupling.



The new flexible couplings N-Eupex ERN with torque limiter (right), N-Eupex B with clamping element (left) and N-Eupex DKS with shortest double-cardanic design (center) of Flender.

www.flender.com

Well-rounded separation technology

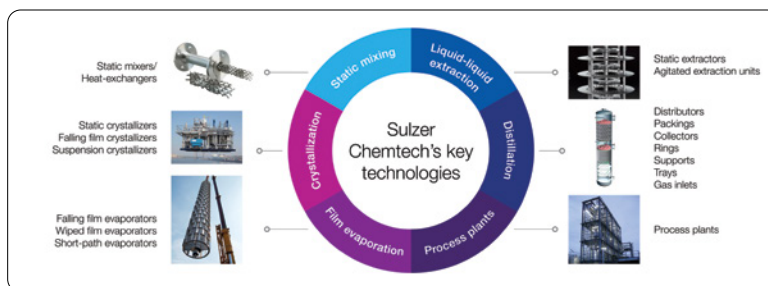
Sulzer Chemtech shares its innovations to support circularity at AICHEMA 2022

Sulzer Chemtech is showcasing its cutting-edge processing solutions for chemical engineering, environmental protection and bio-based production at AICHEMA 2022. Attendees to Stand D48 (Hall 4.0) will be able to interact with the company's leading experts and explore the separation and mixing technologies that can help businesses drive efficiency, sustainability and competitiveness.

ACHEMA, one of the world's leading chemical and process engineering exhibitions, will return to Frankfurt am Main, Germany, to offer a unique platform for industry players to discuss the latest trends and technologies in the sector. As a premier processing technology provider, Sulzer Chemtech will showcase its process plants and mass transfer solutions, placing a particular focus on sustainable production and circular strategies.

During the event, the company's specialists will hold a technical presentation on August 25, from 10:30 a.m. This will discuss the current challenges in plastic recycling and upcycling as well as how innovative purification technologies are helping to address these and support plastic circularity. In particular, the presenters will showcase how Sulzer Chemtech's innovative separation technologies can be used to develop ground-breaking chemical recycling facilities to process a wide range of polymers, including textiles.

Sulzer Chemtech will also display its comprehensive mass transfer portfolio, technology licensing and engineering capabilities on its stand. This will feature a virtual reality (VR) area, where visitors will be able to explore full-scale photorealistic reproductions of real-



As a premier processing technology provider, Sulzer Chemtech will showcase its mass transfer portfolio, technology licensing and engineering capabilities on its stand.

world processing and manufacturing facilities that leverage Sulzer Chemtech's equipment. User will be able to learn how plants can maximize throughput, product quality and energy efficiency, driving their productivity and sustainability. Anyone interested in learning more about Sulzer Chemtech's offering will also be able to discuss how to advance their operations and optimize their carbon footprint with leading experts available on stand throughout the event.

Visit Sulzer Chemtech's stand (Hall 4.0, Booth D48) at AICHEMA 2022, taking place from August 22-26, 2022 in Frankfurt am Main, Germany, by registering at: <https://www.achema.de/en/the-achema/participation>

www.sulzer.com

Trends and mega trends in process engineering

Ystral, the mixing and dispersion technology specialists, take the experience they gain from one industry and apply the solutions in other sectors. This multi-industry approach allows producers to benefit from ystral's extensive knowledge across a multitude of products, processes, and industries.

New technologies, changing production requirements, frequent product changes, and stricter requirements for occupational safety and environmental protection are fundamentally changing manufacturing processes.

Trends in process technology often differ across industries, even for similar processes, as manufacturers do not always have insights into solutions from other sectors. Today's process technology is developing through mega trends such as Smart Factories, digitisation, and modular fabrication.

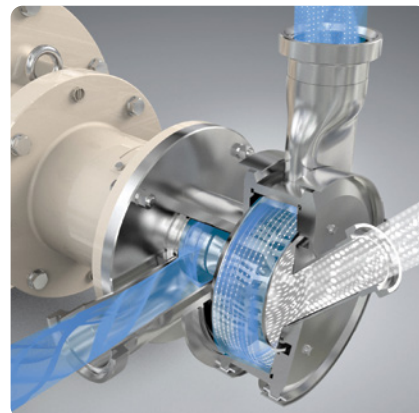


The trends presented by ystral at the exhibition will provide visitors with ideas for solutions of which they might not be aware of – offering unique insights and prompting new ways of improving their manufacturing processes.

Some of the process engineering trends ystral will present at ACHEMA include:

- Cleaning without agents
- Clean production processes without biocides or preservatives
- Cold chemistry
- Possibilities of process intensification
- Realisation of intensive processes outside the tank
- Development from co-grind to slurry manufacturing
- Moving from batch to inline processes

At the exhibition booth in hall 12, stand C68, ystral will show how, within the context of these trends, changing process requirements can be dealt with using innovative mixing and dispersion technologies. The company will present the inline powder wetting and dispersing machine YSTRAL Conti-TDS, the YSTRAL Jetstream Mixer, and



other ystral technologies. Furthermore, the mixing and dispersion technology specialist will introduce the newly developed powder dispersing system YSTRAL BATT-TDS, which reduces the production time of lithium-ion-electrode slurries in battery manufacturing from two- to six hours, to just a few minutes.

Visit ystral in hall 12, booth C68 at Achema 2022 from 22 till 26 August and improve your process! Free tickets and more information available at:

www.ystral.com/achema22

Flow Measurement of H₂, O₂, and Gaseous H₂O

Flexible Industrial Measurement Technology for a Changing World

Over the past three decades, non-invasive flow measurement with clamp-on ultrasonic technology has evolved from a true outsider technology to an outsider measuring technology only in a technical sense. **FLEXIM's** ultrasonic **FLUXUS** flowmeters measure from the safe side: the outside of the pipe. The practical advantages are obvious: No wear and tear by the medium flowing inside the pipe, no risk of leakage, no pressure loss and, above all, unlimited plant availability.

As the technology leader in the field of clamp-on ultrasonic measurement, **FLEXIM** continuously pushes the boundaries and extends its range of applications. Almost twenty years ago, **FLEXIM** was successful in transferring clamp-on ultrasonic technology to the non-invasive flow measurement of gases. Since then, **FLUXUS** flowmeters have been used to measure almost any gas, from compressed air in automotive factories and hydrochloric acid in chemical plants to pure oxygen in hospitals. As non-invasive flow measurement is notably the method of choice when the flowing media is dangerous, the entire value chain of natural gas is a prominent application field for **FLEXIM's**

gas flowmeters. **FLUXUS** measures natural gas even when it is liquid. With **FLUXUS Cryo**, **FLEXIM** developed an ultrasonic system for the non-invasive flow measurement of LNG. **FLEXIM** also has the technology to measure hydrogen. Therefore, **FLEXIM** is not just hydrogen-ready, but experienced and well prepared for the energy transition.

Non-invasive steam flow measurement

FLEXIM offers two complementary non-invasive measuring solutions for low-temperature as well as for high-temperature steam flow measurement. The **FLUXUS ST-LT** series allows for volume and mass flow measurement of saturated and superheated steam at temperatures up to 180 °C. **FLUXUS ST-LT** works according to the ultrasonic transit-time difference principle. Due to its extraordinary measurement dynamics and its high sensitivity even to low flows, **FLUXUS ST** does not require a reduction in pipe diameters in order to achieve a minimum flow velocity. In



Non-invasive flow measurement of 350 °C hot steam on a DN600 line

conjunction with **FLEXIM's** patented high-temperature transducer mounting device **Waveinjector** and the use of correlation flow measuring technology, **FLUXUS ST HT** extends the application range of non-invasive steam flow measurement up to 400 °C. With the new and hazardous area certified portable **FLUXUS G608 ST-LT**, **FLEXIM** offers a veritable multi-tool: in addition to steam, the measuring system can also measure liquids, gases, compressed air and thermal energy.

www.flexim.com

GF Piping Systems atACHEMA 2022

Between August 22 and 26, the company will present innovations for process automation, industrial water 4.0 and solutions such as IR PVC-U welding.

Conserving precious resources is becoming increasingly important. On the way to a more sustainable future, modern technologies that enable better monitoring, control, and transparency in the use of resources are therefore also required in the process and chemical industry. At ACHEMA 2022 in Frankfurt a.M., Germany, **GF Piping Systems** will focus on intelligent automated piping systems for the safe and sustainable transport of chemicals, water, and other media.

Process automation – for the sustainable use of resources

GF Piping Systems will present the Ball Valve 543 Pro, which - equipped with a new pneumatic actuator type PPA and the electro-pneumatic positioner - is made entirely of plastic. As a result, it is maintenance-free and has a service life corresponding to the entire piping system. The 3-way ball valve covers a wide range of applications for every need.

In addition, the first industrial butterfly valve with an environmental product declaration will also be displayed. The plastic Butterfly Valve 565 was introduced in 2021 and has already set a high bar. Its pressure and temperature boundaries are close to those of conventional solutions, and due to its installation length it can easily replace metal alternatives. Corrosion resistance and less abrasion also lead to lower maintenance costs, giving it a big advantage within the market. Its modular design allows customers to fit electric and pneumatic actuators, as well as a smart actuator that can be controlled and monitored remotely. In addition, a unique sensor solution for position feedback can be connected.

Further solutions increasing sustainability

Handling hazardous media requires protecting the environment, employee health and operational safety. In this context, GF Piping Systems will present its double



containment systems CONTAIN-IT Plus designed to prevent leakages. The plastic system is corrosion-free, UV- and weather-resistant, has good chemical resistance, and a smooth internal surface. Its low weight allows easy handling. Further products on display will include IR PVC-U, the world's first infrared-welded PVC-U piping system, as well as ultrasonic non-destructive testing for pipe connections and virtual reality training methods.

Jens Frisenborg, Head of Business Unit Industry & Utility, GF Piping Systems, sees ACHEMA 2022 as an important platform: "We rely on plastic as a sustainable and at the same time highly efficient material for our flow solutions, regardless of whether it involves transporting chemicals, gas, or water. At the ACHEMA, we want to show how modern materials combined with innovative technologies create sustainable connections for life."

www.gfps.com

Suitable materials for the challenges of the Chemical Process Industry

VDM Metals, based in Germany and part of the Acerinox Group since 2020, proves with its versatile product portfolio that it offers precise solutions for the challenges in the chemical process industry, by offering own product developments such as VDM® Alloy 31, VDM Alloy 31 Plus®, VDM® Alloy 59, VDM® Alloy 2120 MoN and the latest development VDM® Alloy 699 XA.

Construction materials for the chemical process industry have to withstand different requirements and need sufficient resistance against a multitude of corrosive media. Oxidizing and reducing conditions, localized corrosion in the form of pitting, crevice corrosion and stress corrosion cracking are some of the potential problems for low alloyed materials. In the petrochemical industry, pressures and temperatures that lead for example to metal dusting are another challenge in plant design and require special properties of the used alloys. The specific composition of the alloying elements of the materials in each case ultimately leads to the required properties and resistances required.

As different as these materials are, the former are the most widely used materials in equipment for many applications subjected to the above mentioned conditions. VDM Alloy 699 XA exhibits very good resistance to metal dusting, all these alloys are characterized by very good workability, weldability and availability in a wide range of product forms.

Regarding wet corrosion resistance, VDM Alloy 31 and VDM Alloy 31 Plus® perfectly bridge the gap between normal stainless steels and Nickel Alloys and in some applications are even superior to more expensive alloys.

Typical applications of VDM® Alloy 59 are plant components for organic chemistry processes with media containing chloride, scrubbers, heat exchangers, flaps, ventilators and agitators for flue gas desulfurization (FGD) in fossil fuel power plants and waste combustion plants, equipment and components for geothermal energy and acid gas applications, reactors for acetic acids and acetic anhydrides and for



hydrofluoric acid as well as sulfuric acid coolers.

The range of application of VDM® Alloy 2120 MoN is even more extensive due to its superior corrosion resistance. It can be used in the chemical, petrochemical and pharmaceutical industries as well as in energy production and environmental technologies.

VDM® Alloy 699 XA, has a well-balanced metal dusting resistance, excellent processability and weldability and in addition to its resistance to metal dusting corrosion, the material is characterized by its good thermo-mechanical properties and microstructure stability. VDM® Alloy 699 XA was designed for the special demands in the petrochemical industry in syngas processes for the production of hydrogen, ammonia, methanol and cooling of syngas during e-fuel production.

The alloys are available as bar, sheet, plate, wire and powder for additive manufacturing. Matching filler metal for each alloy completes the offer of VDM Metals.

www.vdm-metals.com

Steel belt units for ceramic tapes

Ceramic tapes play a key role in certain advanced ceramics and as separators in fuel cells and components in solar cells. Governmental incentives to develop green technologies are moving society from fossil fuels to hydrogen energy. Additionally, the growing demand for MLCC (Multi-Layer Chip Capacitors) for 5G communication, IOT (Internet of things) and electrification in the automotive industry highlight the importance of ceramics more than ever.

IPCO designs and manufactures complete lines for the production of Ceramic Tapes

Tape casting units are mainly based on steel belt technology. The production line begins with a slot die or a casting box that applies an accurate controlled layer of a slurry directly onto a polished steel belt or a carrier foil. From there it passes through different dryer zones, which are configured based on the slurry characteristics. The dryer utilizes a combination of conventional tangential flow, impingement or IPCO's patented Venturi drying technology to quickly evaporate the aqueous or organic solvent. The result is a drying efficiency that leaves the final material almost completely free of tension both laterally and longitudinally.

The high precision drying concept improves the overall casting process, enabling the production of ceramic tapes to exceptionally narrow tolerances without any risk of skin formation. It also increases yield by eliminating costly faults and imperfections in the final material.

IPCO Venturi dryer

IPCO's on-going investments in R&D, coupled with our proven experience and expertise in film processing technologies has resulted in the successful development of an innovative Venturi drying zone. When integrated properly, the Venturi drying technology significantly improves the efficiency of the drying process (higher throughput per m²) and decreases energy consumption.

www.ipco.co

EKATO – Your Partner to bring Advanced Plastics Recycling to Commercial

Plastic pollution – nowadays having a tremendous public awareness – has raised the demand for new and efficient recycling processes

Chemical plastic recycling, also called advanced recycling, refers to several different technologies that convert used plastics into their original building blocks, feedstocks for new plastics or other valuable products. The aim is always to split the polymer chains into shorter hydrocarbons, which is achieved with the help of either heat, catalysts, solvents, water or UV-light.

EKATO's process plants section is specialized to help grow these new processes to commercial

Besides customized assistance to solve problems and optimize processing solutions EKATO is in the position to perform laboratory and pilot plant investigations. A main challenge in the development of any chemical plastics recycling process is the scale-up. Here EKATO's long-term experience in

process industry – in most different processes all around the agitated reactor – is the basis for a successful development together with the corresponding partner who owns the process.

EKATO's process plants department is in the position to realize plastics recycling projects with extreme short time-to-market. As process design, engineering, complete pilot plants or even commercial modular skid-mounted units can be provided out of one hand, EKATO is the one stop shop solution for partners who intend to rapidly bring their environmental-friendly plastics recycling process to commercial scale. www.ekato.com



EKATO Pilot facilities allow safe and robust scale-up to production size

Electric actuators for Industrial Ethernet

AUMA actuators support Profinet, EtherNet/IP and Modbus TCP

Profinet, EtherNet/IP, Modbus TCP – Industrial Ethernet protocols are increasingly gaining ground for field device integration in the chemical process industries. Offering outstanding connectivity, combined with simple and robust transmission technologies, these protocols are key enablers for enhanced data integration, intelligent analytics and IIoT applications.

AUMA electric actuators support these standards and can be easily integrated in Profinet, EtherNet/IP and Modbus TCP environments, enabling plant managers to fully benefit from the enormous potential to optimize processes and maximize plant availability.

With bandwidths up to 100 Mbit/s, AUMA actuators provide reliable and rapid exchange of both cyclic process data and acyclic diagnostic data from the actuators. The wide range of diagnostic data that is automatically logged by the actuators is immediately available at network level and can



AUMA electric actuators support the Industrial Ethernet standards Profinet, EtherNet/IP and Modbus TCP, making the multiple benefits of Industrial Ethernet utilisable at field level.

be further used for analysis, process visualization, or simulation, facilitating condition-based predictive maintenance and efficient asset management.

Providing utmost flexibility, the actuators can be integrated into line, star and loop topologies, using different transmission media such as copper cables, optical fibres and wireless technologies. AUMA provides standardised device descriptions as GSDML or EDS files and Field Device Integration Packages, thus facilitating device integration. www.auma.com

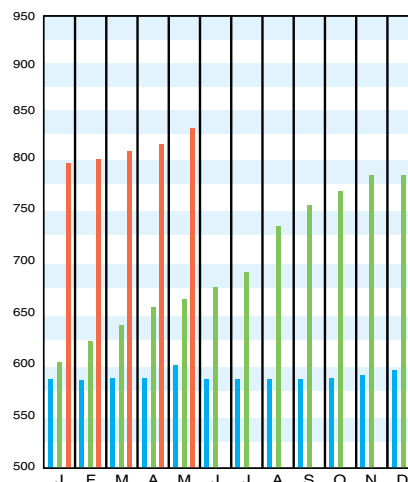
Download the CEPCI two weeks sooner at www.chemengonline.com/pci

CHEMICAL ENGINEERING PLANT COST INDEX (CEPCI)

(1957-59 = 100)	May '22 Prelim.	Apr. '22 Final	May '21 Final
CE Index	831.7	816.3	686.7
Equipment	1,057.1	1,037.1	848.5
Heat exchangers & tanks	902.4	876.0	726.6
Process machinery	1,074.9	1,063.9	862.9
Pipe, valves & fittings	1,496.7	1,472.8	1,160.6
Process instruments	575.5	573.5	507.5
Pumps & compressors	1,255.1	1,248.9	1,115.6
Electrical equipment	757.3	751.8	601.0
Structural supports & misc.	1,176.8	1,144.7	915.0
Construction labor	354.6	348.3	341.7
Buildings	847.2	827.0	739.2
Engineering & supervision	311.5	311.8	310.4

Annual Index:

2014 = 576.1
2015 = 556.8
2016 = 541.7
2017 = 567.5
2018 = 603.1
2019 = 607.5
2020 = 596.2
2021 = 708.0



Starting in April 2007, several data series for labor and compressors were converted to accommodate series IDs discontinued by the U.S. Bureau of Labor Statistics (BLS). Starting in March 2018, the data series for chemical industry special machinery was replaced because the series was discontinued by BLS (see *Chem. Eng.*, April 2018, p. 76-77.)

CURRENT BUSINESS INDICATORS

CPI output index (2017 = 100)	
CPI value of output, \$ billions	
CPI operating rate, %	
Producer prices, industrial chemicals (1982 = 100)	
Industrial Production in Manufacturing (2017 = 100)*	
Hourly earnings index, chemical & allied products (1992 = 100)	
Productivity index, chemicals & allied products (1992 = 100)	

LATEST

May '22 = 101.7
Apr. '22 = 2,082.8
May '22 = 80.8
May '22 = 367.8
May '22 = 103.1
May '22 = 199.6
May '22 = 91.8

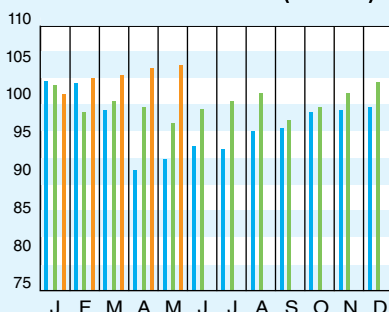
PREVIOUS

Apr. '22 = 101.3
Mar. '22 = 2,088.1
Apr. '22 = 80.5
Apr. '22 = 358.5
Apr. '22 = 103.2
Apr. '22 = 196.7
Apr. '22 = 93.8

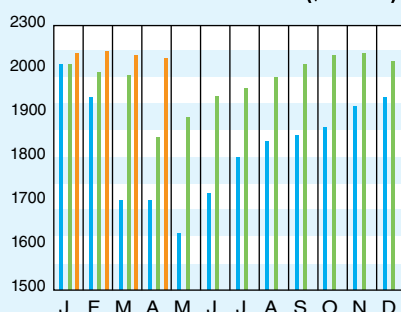
YEAR AGO

Mar. '22 = 101.0
Feb. '22 = 2,004.7
Mar. '22 = 80.3
Mar. '22 = 354.2
Mar. '22 = 102.4
Mar. '22 = 195.9
Mar. '22 = 93.5
May '21 = 97.5
Apr. '21 = 1,706.0
May '21 = 77.7
May '21 = 310.7
May '21 = 98.4
May '21 = 93.8

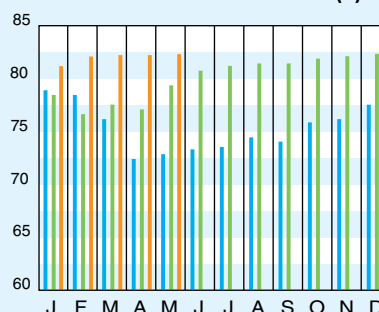
CPI OUTPUT INDEX (2017 = 100)†



CPI OUTPUT VALUE (\$ BILLIONS)



CPI OPERATING RATE (%)



*Due to discontinuance, the Index of Industrial Activity has been replaced by the Industrial Production in Manufacturing index from the U.S. Federal Reserve Board.
†For the current month's CPI output index values, the base year was changed from 2012 to 2017
Current business indicators provided by Global Insight, Inc., Lexington, Mass.

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CURRENT TRENDS

The preliminary value for the CE Plant Cost Index (CEPCI; top) for May 2022 (most recent available) is once again higher than the previous month's value, continuing the string of monthly increases that has been observed since autumn 2020. In May of this year, increases occurred in the Equipment, Buildings and Construction Labor subindices, while the Engineering & Supervision subindices saw a very small decrease. The current CEPCI value now sits at 21.1% higher than the corresponding value from May 2021. Meanwhile, the Current Business Indicators (middle) show increases in the CPI output index and the CPI operating rate for May 2021, and a small decrease in the CPI value of output for April 2021.